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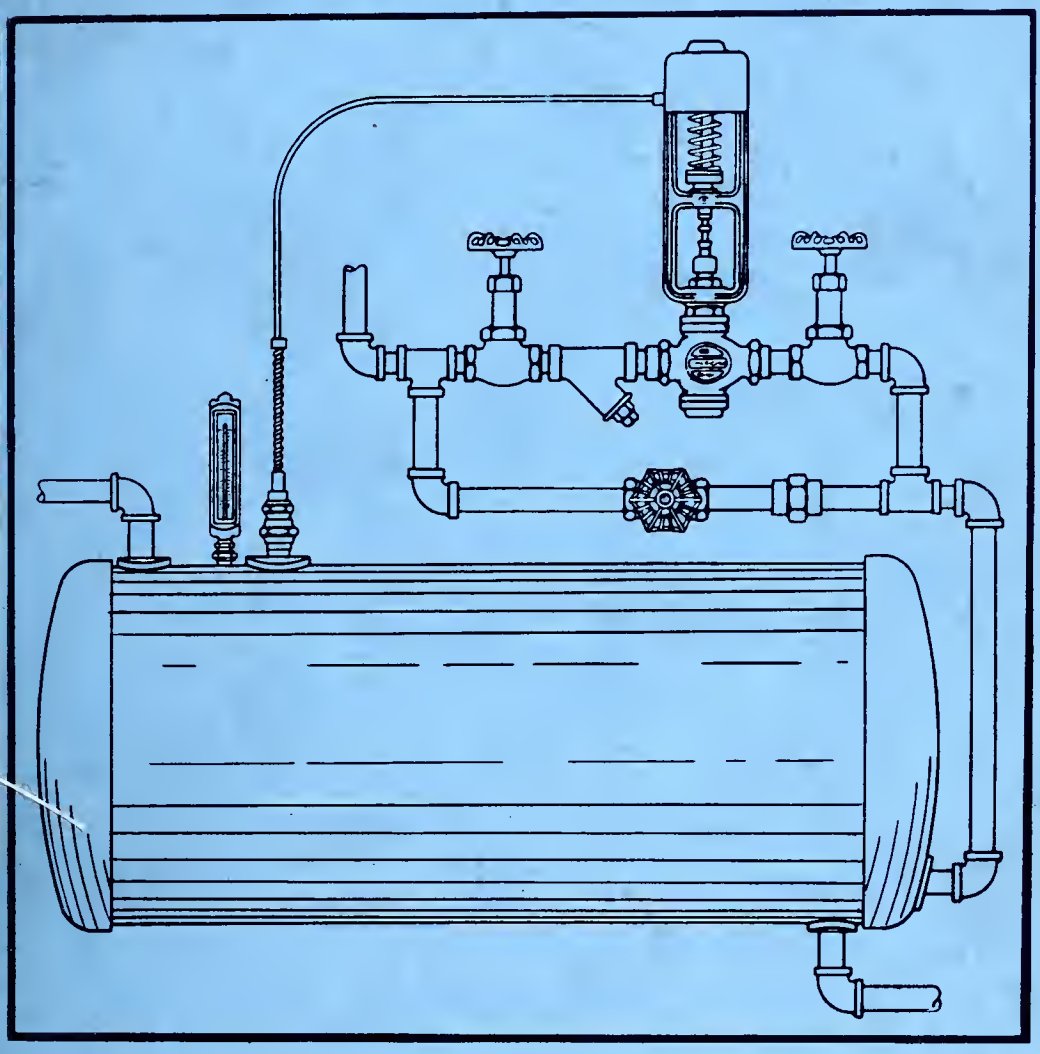

BULLETIN 345-O

Commonwealth of Pennsylvania
DEPARTMENT OF PUBLIC INSTRUCTION
1944

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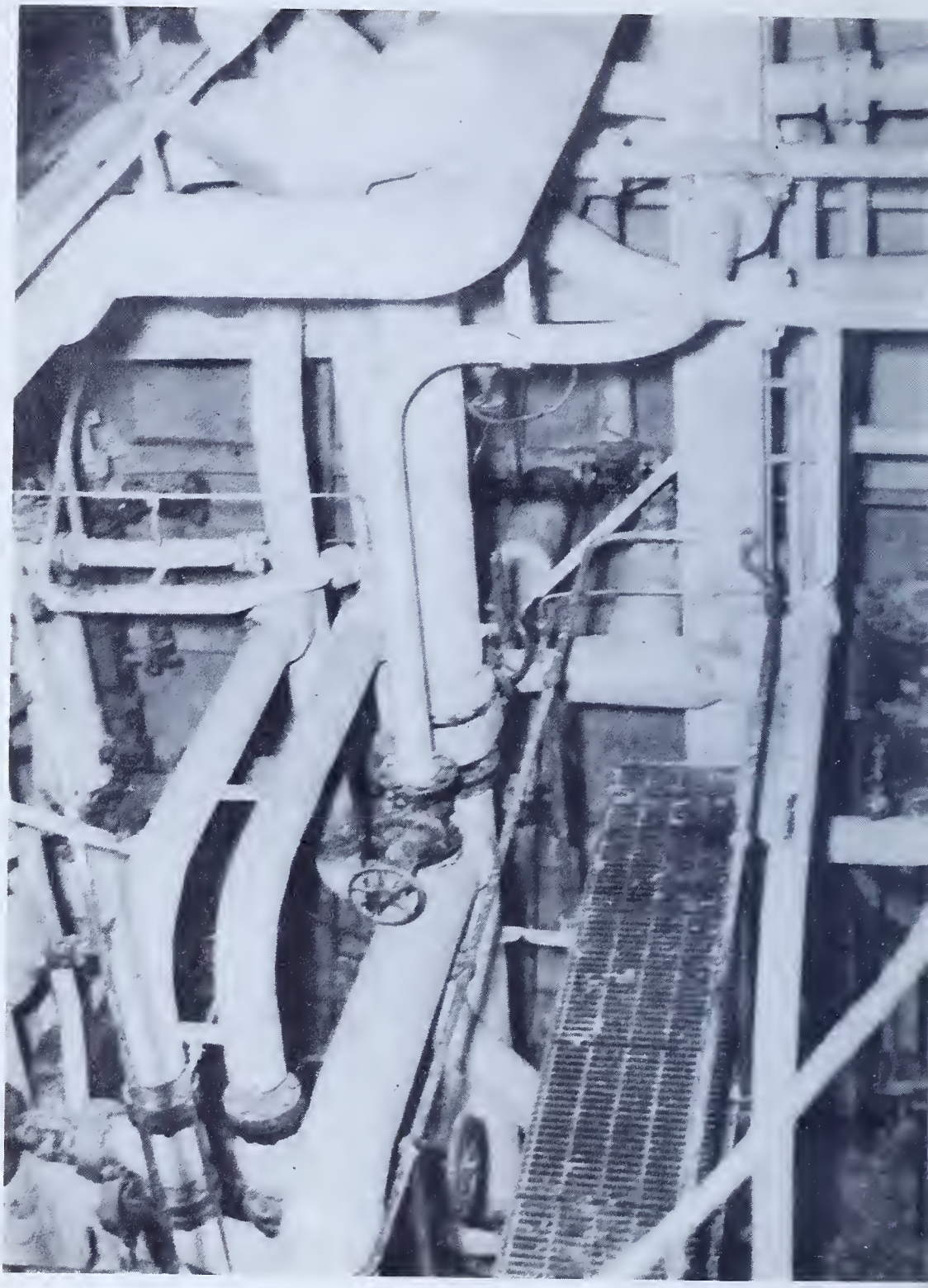
Vocational Training
for
War Production Workers



Piping Installation Found in the Engine Room of a Tanker

MARINE PIPEFITTING

(A Manual of Instruction for Beginning and Advanced Marine Pipefitters)

Bulletin 345-O

Prepared by the

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF PUBLIC INSTRUCTION
DIVISION OF INDUSTRIAL EDUCATION

In Cooperation With

SUN SHIPBUILDING AND DRY DOCK COMPANY
CHESTER, PENNSYLVANIA

SCHOOL DISTRICT, CITY OF CHESTER
CHESTER, PENNSYLVANIA

and

UNITED STATES OFFICE OF EDUCATION
FEDERAL SECURITY AGENCY

Commonwealth of Pennsylvania
DEPARTMENT OF PUBLIC INSTRUCTION
Harrisburg
1944

This Material Was Prepared
In Cooperation With the
United States Office of Education
The Federal Security Agency
Washington, D. C.

Foreword

The necessity for training large numbers of war production workers in Marine Pipefitting has prompted the development of this instructional material.

The units comprising this manual have been organized and developed with the assistance of experienced foremen and mechanics, men who are specialists in shop fabrication and assembly, in making installations aboard ship, and in general repairing and maintenance of all types of piping systems.

The procedures presented are specifically those which are followed in the yard of the Sun Shipbuilding and Dry Dock Company. Many of the methods and procedures will be found applicable in training marine pipefitters to meet similar shipbuilding situations wherever workers may be employed in this occupation.

Acknowledgment is made to the Sun Shipbuilding and Dry Dock Company, Chester, Pennsylvania, for assistance and cooperation in making the preliminary analysis and in preparing instructional materials.

Special acknowledgment is extended to George D. Carney, General Superintendent in charge of Mechanical Installations; Clayton Tourville, General Foreman of Pipefitting; A. Weigand, Leaderman in the Lead Pipe Installations; C. Kirschbaum, Leaderman of Hanger Installations; Marlin McCrone, Leaderman of Ship Installations; and Eugene Perkins, Leaderman of Ship Installations, for materially assisting in the preparation of text material, sketches, and photographs. These men served as technical advisers during the preparation of this manual.

Special acknowledgment is extended to J. F. Donlevie, Leaderman of the Pipe Shop for his excellent work in developing the section "Short Method for Bending Pipe". This method is used extensively in the Sun Shipbuilding Yard.

Appreciation is extended to William A. Brock, Coordinator of Industrial Education, to the Chester School District, and to D. Francis Hallowell, Coordinator of Chester Area Vocational Training for War Production Workers, for assistance in this work.

This manual of instruction was prepared at the Chester Field Curriculum Laboratory of the Pennsylvania Department of Public Instruction. Charles Johnston, Adviser, Division of Industrial Education; Lyle Weissenfluh, Analyst; and Victor Hensel, Analyst; supervised the preparation of materials at the Laboratory.

This unit was completed under the direction of Charles F. Zinn, Chief, Division of Industrial Education, and under the general supervision of Paul L. Cressman, State Director of Vocational Training for War Production Workers.

FRANCIS B. HAAS
Superintendent of Public Instruction

January, 1944

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PART I

SAFE PRACTICES IN MARINE PIPEFITTING

Introduction

There are danger hazards in all industrial plants and a shipyard is no exception. Many if not most of the materials handled in the shipyard are very heavy and cumbersome. These heavy pieces or assemblies are lifted over the heads of workmen by cranes. This provides the everpresent danger of being crushed by falling objects or of being pushed off balance into a serious fall. Because shipbuilding must be carried on close to water, walks and ladders are usually wet and slippery. Then, too, the machine tools, rivet guns, pneumatic tools, portable grinders, etc., create such a din and uproar that the workman cannot depend upon his sense of hearing to warn him of approaching danger. The pipefitter must be aware of these dangers while going back and forth between the ship and the shop, while working in the shop, and while working aboard ship.

The easiest way of preventing dangerous accidents or injuries is to heed all safety rules and precautions. *VERY FEW ACCIDENTS ARE UNAVOIDABLE.* The pipefitter is subject to all of the accidents common to the shipyards; consequently he should be thoroughly acquainted with the essential safety rules and safety precautions practiced in the shipyard.

ACCIDENTS ARE WASTEFUL. They inflict a loss upon the company, upon the personnel involved, and upon the nation in terms of loss in man-hours and consequent loss in production.

Safety Instruction in Shipyard Work

PHYSICAL FITNESS

A. Physical Examination Requires:

1. Good health
2. Ability to climb
3. Strength enough to do some lifting

B. Keeping Physically Fit for the Job Requires:

1. Plenty of sleep
2. Proper food
3. Abstinence from liquor

TYPICAL SHIPYARD HAZARDS

1. Danger of Falling
   a. Unsafe footing
   b. Presence of objects which would make footing hazardous, such as scrap or oil
   c. Insecure staging, spawls, or other working supports
   d. Improper treatment of guard rails — improper use of tools
   e. Improper shoes — loose soles, trailing shoe laces
   f. Tripping over hose, burning and welding lines, electric feed wires
   g. Failure to replace staging which has been moved

2. Danger From Falling Objects
   a. Exceeding safe working loads of equipment which may result in breakage
   b. Insecure fastening of loads
   c. Poorly applied or unsafe lifting pads
   d. Leaving loose objects where they may slide off the vessel or staging
   e. Leaving tools in precarious positions
   f. Danger of dropping tools while using them
   g. Danger of dislocating planks, small parts, or other objects in swinging a load with a crane
   h. Carelessly throwing scrap from the ship
   i. Improper shoring
   j. Working under loads being lifted or erected

3. Danger From Inadequate Personal Protection
   a. Loose clothing, especially legs of trousers or overalls
   b. Lack of safety shoes
   c. Lack of safety helmets
   d. Lack of goggles where necessary
   e. Lack of proper eye shields around welding operations
   f. Foolhardy risks
   g. Improper use of tools and equipment
   h. Daydreaming

Types of Safety

Safety means more than merely "being careful". In that the shipyard worker is largely dependent upon the careful and conscientious adherence to safety provisions on the part of workmen who may have preceded him on a job, it is the duty of every workman to consider not only his personal safety, at the time of doing a piece of work, but also any possible effect which the work he is doing may have upon the safety of those who must work after him or below him.

Wearing Safety Hat and Safety Shoes

It is advisable for a ship pipefitter to wear a safety hat and safety shoes at all times. These items may be obtained from the safety store of the company.

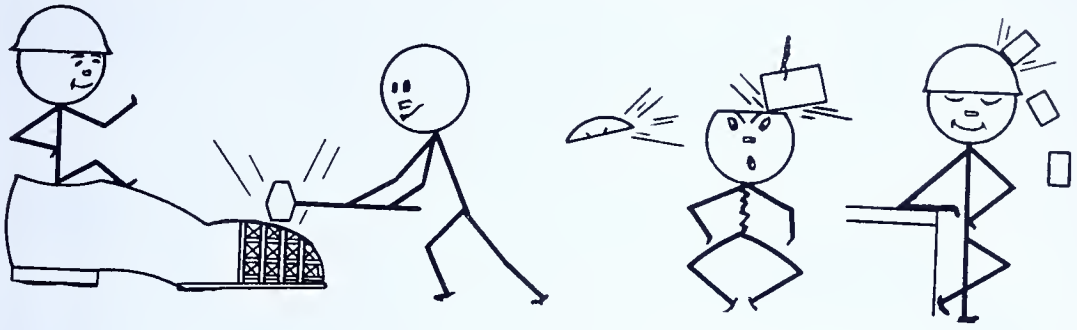


Fig. 1 — *Safety Shoes and Hats*

Avoiding Loose-Fitting Clothing

An employee should wear clothing that is suitable for his work. Ragged sleeves, gloves, loose sweaters, ties, trouser legs and other parts of clothing which can be caught in machinery or on protruding objects should not be worn.

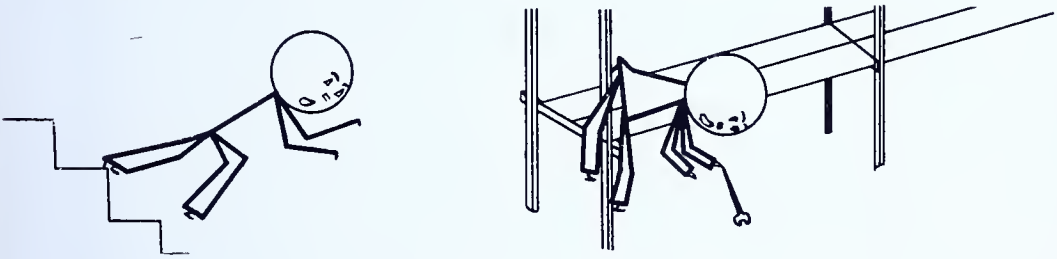


Fig. 2 — *Loose Clothing*

Handling a Pipe Properly

When carrying a length of pipe, it is always advisable when nearing a corner or a doorway to have the front end of the pipe raised high enough so that the end of the pipe will be over the head of a man who may be coming around the corner or through the doorway. Then the end of the pipe will not strike him in the face.

When hanging pipe, always be sure that it will hold your weight. This will protect someone else who may be careless and try to support his weight on the piping while working.

Safe practice calls for the use of hangers that are required by the specifications for the job. A rope should never be used to hang pipes under the deck, or as temporary sup-

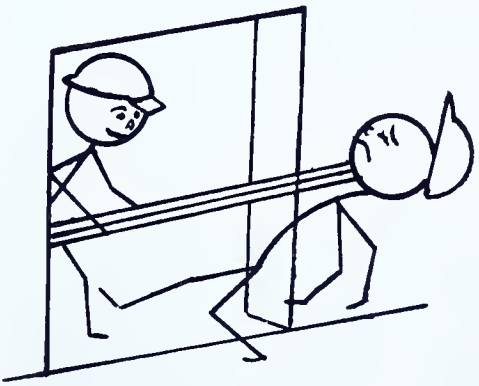


Fig. 3 — *Carrying Pipe*

ports on which to wire the pipe. Use strong wire which will remove the danger of injury or of having the pipe line knocked out of place. A spark from a welder's torch may burn a cord or rope and so weaken the rope that it will be useless.

In the shop and in the yard, it is often necessary to lift heavy pipe, valves, or fittings. The correct procedure is to keep the feet together, using the knees as a fulcrum in lifting.

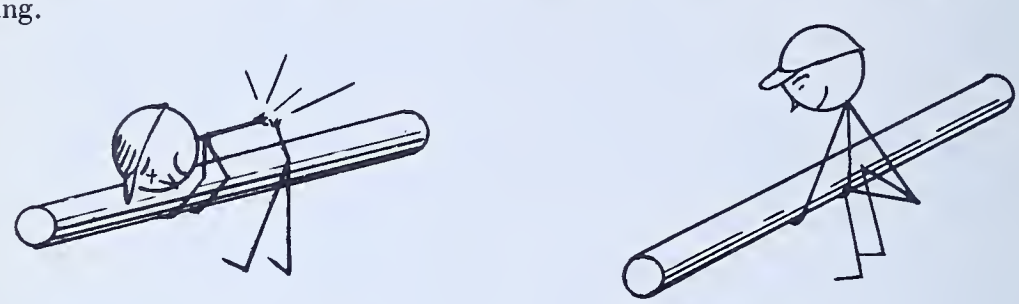


FIG. 4 — *Picking Up Pipe*

Care must be exercised at all times when working around pipe that has been heated for bending. It is essential to have adequate protection on the hands, and to avoid touching the heated portion of the pipe, as it may cause severe burns. All heated pipe should be marked "hot" with soapstone or chalk.

HANDLING TOOLS AND EQUIPMENT PROPERLY

In order to guard against hazards in the pipefitting department and on the ship, the following rules should be observed at all times:

1. Keep all tools and equipment in their proper places when not in use.
2. Do not leave tools and equipment lying on the floor, around machinery, on walkways or staging to present a serious hazard to all employees.
3. Return defective tools to the tool room.

   For example, the use of a wrench with worn jaws may cause the wrench to slip, and the result may easily be injured or broken fingers.
4. Do not wrap the fingers around the handle of the wrench when working near a solid object.

   If the wrench should slip, the fingers may be smashed against the solid object. Use the palm of the hand and keep the fingers free.

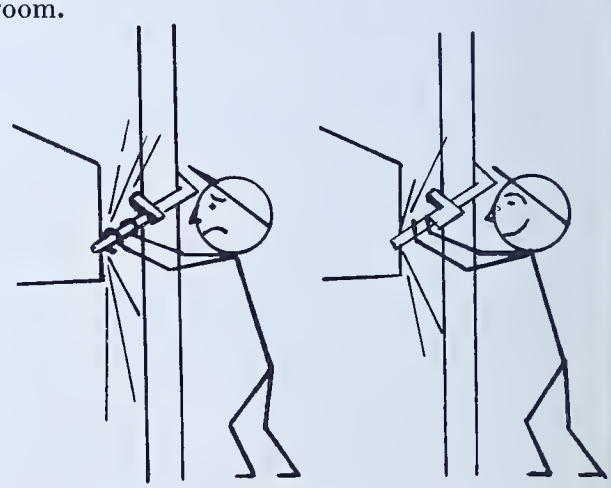


FIG. 5 — *Handling of Tools*

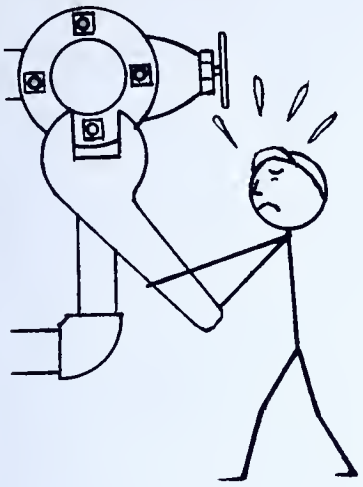


FIG. 6 — *Correct Size Wrench*

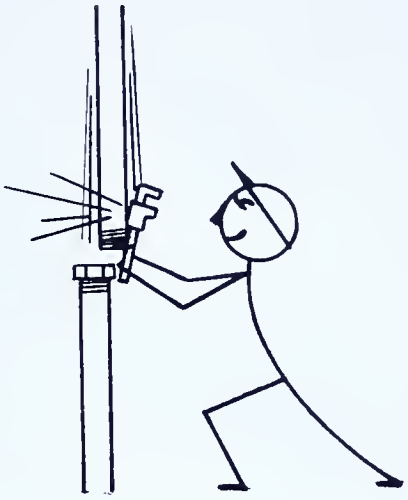


FIG. 7 — *Use a Hammer*

5. Use the correct size wrench for the job.

   The size of the opening is usually stamped on open-end wrenches to aid the pipefitter in selecting the suitable wrench. When too large a wrench is used, the corners of the nut are chewed off, making it difficult to get the nut on or off. Open-end wrenches are designed to withstand a pull on the handle about equal to the same force a bolt will withstand.

6. Never use a wrench as a hammer.

   A battered wrench always gives trouble.

7. Do not operate a machine without permission.

   Several machines in the pipefitting department have permanent operators. The operator is the only one permitted to use the machine.

8. Do not oil machinery while it is in motion.

9. Do not remove guards from around a machine while it is being repaired.

10. Do not remove guards from a machine without specific instructions from the foreman to do so.

Other Safety Practices

Avoiding Damage to Hose Lines

Not all hazards in handling assemblies result from objects striking workmen; the cutting or breaking of welders' or burners' hose lines may be just as dangerous as being struck by a steel plate. The gas used by burners and welders, and by the rivet heaters, is a highly explosive gas called "propane". When pure, this gas burns; when mixed with the right amount of air, it becomes highly explosive. It is especially dan-

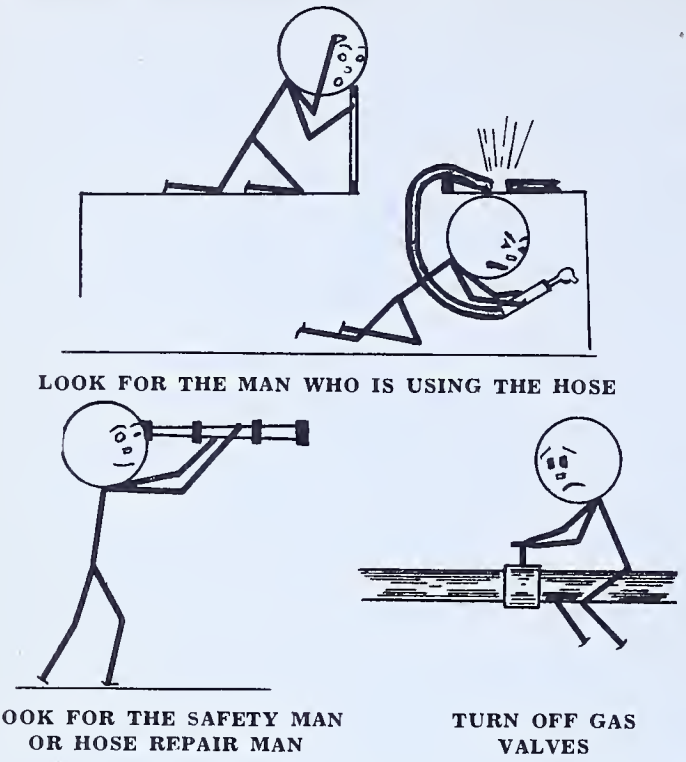


FIG. 8 — *Act At Once When Hose Lines Break*

gerous, because it is heavier than air and drops toward the ground instead of rising and dissipating in the air like other gases. Some yards use acetylene for burning. Propane and acetylene are highly explosive when mixed with the correct amount of air. In addition, both of these gases burn freely when ignited. If any oxygen hose should be damaged at the same time that a break has occurred in an acetylene or propane hose line, the resulting explosion which may take place will be even more violent. In that most of these gases are heavier than air, any escaping gas tends to collect in the lower enclosed portions of the vessel. To ignite escaping gas it is not necessary for the spark or flames to be near the damaged line; a welder's arc or a burner's flame, at a considerable distance, may ignite a low-lying blanket of gas. The flame will follow this combustible line of gas back to its source.

Gases, when mixed with air or oxygen, are especially dangerous when confined. In that the heavier gases tend to accumulate or "flow" to the lowest part of the vessel, a workman in the double bottom or any enclosed space may be subjected to approximately the same danger which would be present if he were locked in a powder magazine. One spark, or a lighted match, would be followed by a violent explosion.

To avoid damaging hose lines, block all materials securely so as to provide safe clearance for these lines.

Identifying Hose Lines

The gas hose used for rivet-heaters' pots is made of smooth, black rubber; it is about 1¼ inch in diameter. The oxygen hose and the acetylene are about ⅝ inch in diameter. Used in pairs of red and black, the red hose carries the propane or acetylene gas.

Reporting All Hose Leaks

Every time a hose is damaged, production is retarded. The first concern is to protect workmen by warning them of the danger and shutting off the valves. So that unnecessary time may not be lost, the hose repairman should be notified at once.

Standing Clear of Loads

Stand clear of loads at all times. No matter how well a load is fastened, there always is a chance that tackle might slip or that a cable or chain might break.

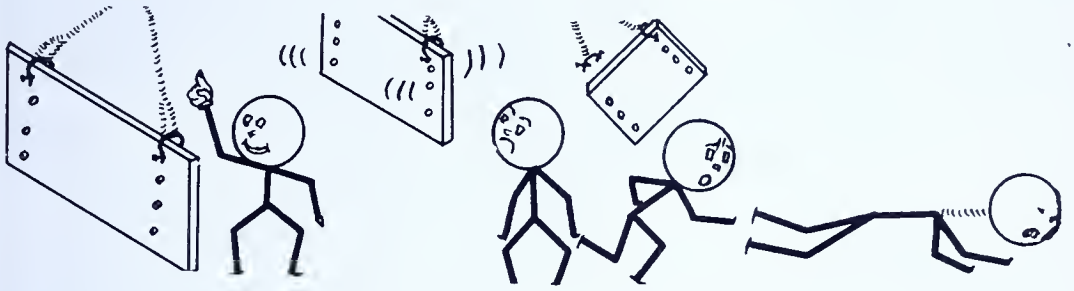


Fig. 9 — *Hoisting Materials*

Pipes are lowered into and pulled out of the hold of a ship by means of ropes. These ropes must be tied securely, and be in good condition. If there is a flange or some connection on the pipe, any good knot will be sufficient to hold the pipe, but where there is no flange or connection, two clove hitches should be tied around the pipe to hold it. A clove hitch is not difficult to tie. It is used, because it gets tighter as the pull becomes greater, and when the pull is slacked, it is easy to untie.

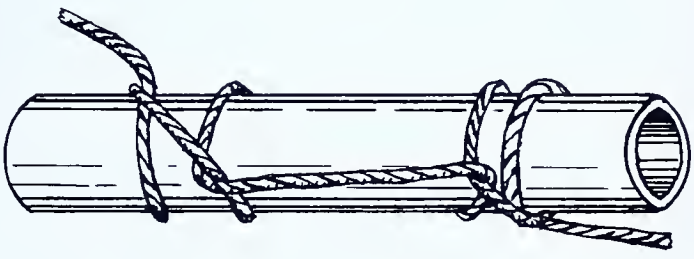


Fig. 10 — *Clove Hitch*

Handling Objects Carefully

In handling objects take precautions which will protect from injury persons working near you or under you. Avoid dropping nuts, bolts, washers, or other objects. Also, avoid placing objects on staging or other surfaces where it is possible for them to be dislodged by yourself or others. Loose objects are dangerous in two ways:

1. They may be dislodged, injuring persons working underneath.
2. The workman on the staging or deck may trip over loose objects, resulting in a serious fall.

Reading Bulletins

Employees should observe the safety bulletins posted throughout the shipyard. These bulletins present safety precautions in a practical way. If read and followed, they will help to prevent accidents. Do not disregard warning signs; to do so may cause an accident to yourself or fellow employee.

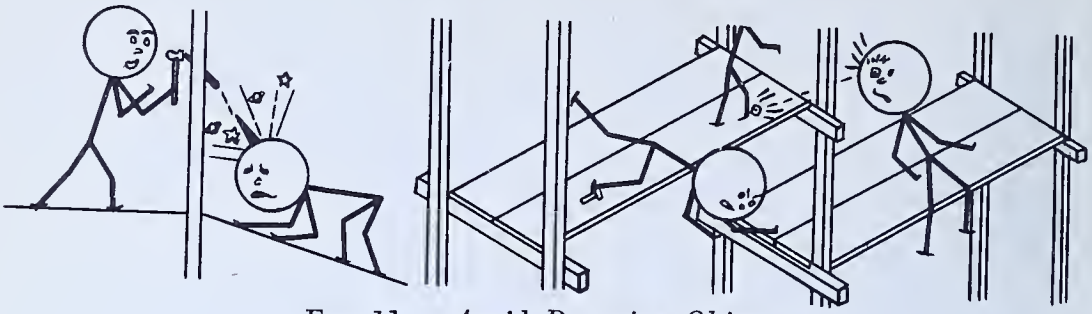


FIG. 11 — *Avoid Dropping Objects*

TAKING SHORT CUTS

Do not take short cuts when passing to and from work. Use the regular routes as indicated.

PRACTICING GOOD HOUSEKEEPING

Lavatories and toilets are provided in convenient places. It is the duty of every employee to keep them clean. Unsanitary conditions should be reported to the proper authorities.

A good worker is also a good housekeeper. The area around the job must be kept as clean and orderly as possible. Never leave tools or materials lying overhead or around the job. If there are timbers with nails sticking in them, bend the nails and remove the timbers. Keep machinery, fire-protective equipment and safety devices free and easily accessible.

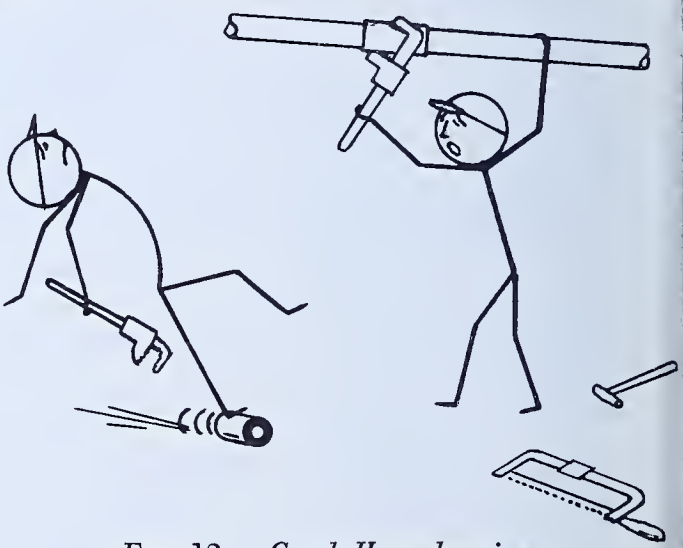


FIG. 12 — *Good Housekeeping*

Never climb a ladder that is unsafe or insecure.. Face the ladder and use both hands whenever possible. Tools and materials can be hoisted to the place in which they are going to be used.

AVOIDING CARELESS PILING OF MATERIAL

Pipe, valves, and other materials should be stored in the yard and in the shop in a place that will afford accessibility as well as being out of the way of operations. Pipe should be piled in such a manner that there will be no danger of its falling.

PROTECTING EYES

Always wear proper protective goggles. Painful eye injury may result from look-

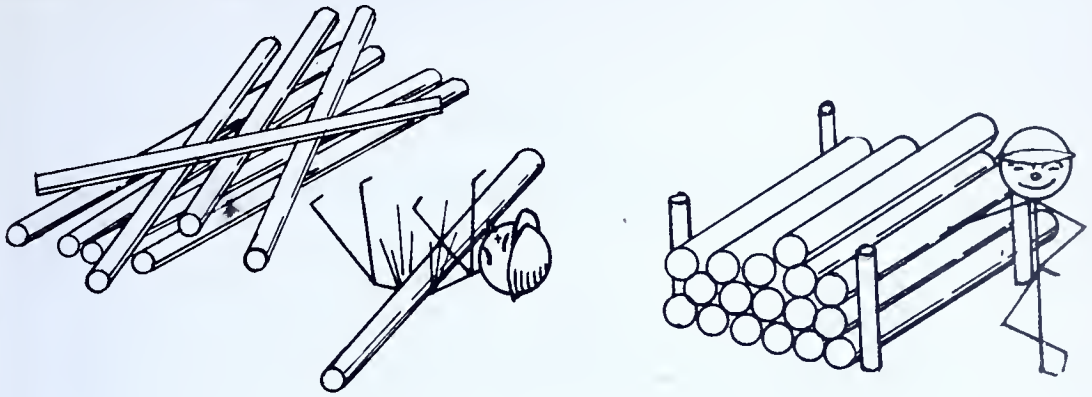


FIG. 13 — *Piling Pipe*

ing at a welding arc. Goggles are available at all tool rooms. Make certain that the goggles furnished are the correct type for the work to be done.

SAFETY DEPARTMENT

A safety department is located within each shipyard. The duty of the safety engineer is to note the common hazards, to be alert for new dangers, and to study accident reports, so that the recurrence of accidents may be prevented. It is the duty of every worker to cooperate with the safety engineer by practicing safety measures, and by reporting to the proper safety officials any particular hazards that the worker has observed.

SAFETY MAN

Safe practices on each ship are under the supervision of a safety man. Each workman on a ship should learn to know his safety man personally and to recognize him by sight, so that he may be quickly located when needed.

It is the duty of the safety man to encourage and to direct men to work safely, and to provide for the installation of any device which may eliminate hazardous conditions and potential causes of injury aboard ship. In the Sun yard the safety man is easily recognized by the yellow safety helmet which he wears.

QUESTIONS

1. What are the physical requirements for a marine pipefitter?
2. Name some of the hazards encountered by the marine pipefitter.
3. Explain why safety helmets should always be worn when working aboard ship.
4. List several dangers arising from wearing improper clothing.
5. Explain the proper method of lifting heavy objects.
6. Explain why defective tools are dangerous.
7. Why is the use of rope as a temporary pipe support considered dangerous?
8. What danger may be present when a hose line leaks or becomes broken?
9. What knot should be used to hold pipe while it is being raised aboard ship or lowered into the hold of a ship?
10. What is meant by good housekeeping?
11. What should be done when a dangerous condition is seen?

PART II
LOCATION OF THE UNITS OF A SHIP

General Arrangement of a Ship

In that a marine pipefitter is primarily concerned with the installation of pipe and necessary fittings in almost every part of the ship, it is important for him to know the general arrangement of a ship. In order to lay out his work, the marine pipefitter should know just what each bulkhead, longitudinal, stringer, frame, or deck, represents. It is plain to see that the pipefitter's work ties in with the ship's structure, and that if he is unfamiliar with this structure or how the structure fits together he will be seriously handicapped when he undertakes to lay out a piping job.

Shipbuilding terms and definitions appear in the glossary.

The shell plating of a ship is the outside surface, or covering, from and including the flat keel, outward and up the side to the level of the deck, and from end to end of the ship. This shell plating forms the ship's watertight covering which makes it float. The plating, supported by frames, must be able to withstand the pressure of the water as well as other stresses due to waves or contact with the dock.

Bulkheads give the ship contour, rigidity, and strength. They serve to separate the tanks and divide the ship into separate tanks or watertight compartments. These bulkheads are defined as transverse bulkheads and longitudinal bulkheads. All pipe lines as well as all doors through these bulkheads must be watertight. Doors are fitted with gaskets so that they can be made watertight, and they must be kept free of any obstruction or material so that they can be closed instantly. All transverse bulkheads extend athwartship, and all longitudinal bulkheads extend lengthwise of the ship. Figure 14 (the starboard side elevation of a tanker) shows the bulkheads marked by dashed lines, and the transverses are easily distinguished from the longitudinals. The cargo tanks are numbered from No. 1 to No. 9 in numerical order beginning at the forward cofferdam, and proceeding aft to the after cofferdam. Each of these cross-section tanks is divided into three parts: one wing-tank, port side; one center cargo tank; and one wing-tank, starboard side. All of these together make a total of twenty-seven cargo-carrying tanks, each separated from adjoining tanks by a watertight bulkhead or an oiltight bulkhead. The first bulkhead aft of the stem is known as the collision bulkhead, and its purpose is to limit flooding after a collision. Double-bottom tanks also are added protection to the ship against damage. If the ship's outer bot-

tom is pierced by grounding or some similar accident, ordinarily only one or two of these tanks will be flooded. These tanks are used to carry fresh water, fuel oil, or salt-water ballast.

The *forward and after cofferdams* are placed between the oil (inflammable) cargo and the dry compartments to form an air seal, or safety compartment, between the different parts of the ship.

The *pump rooms* (one or more) are the source of the majority of pipe lines. A pipefitter should learn the location of the pump room, or rooms, as soon as possible. Pump rooms are the compartments where the pumping machinery is located.

Fuel-oil tanks, one forward and one aft, are used for the ship's supply of fuel oil.

The *dry-cargo* space is used for cargo or supplies that are not in a liquid form.

The *chain locker*, just above the forepeak, is used for storage of anchor chain.

The *forepeak* is a dry buoyancy space, except when used as a ballast tank to level a ship.

The *upper deck* is the main deck on a tanker and extends from one end of the ship to the other. It is called the upper deck, main deck, or shelter deck.

The *forecastle deck* is immediately above the upper deck at the forward end. The *bridge deck* is immediately above the upper deck amidship. The *boat deck* is above the bridge deck and is so called because the lifeboat stations are placed there.

Above the boat deck is the *navigation bridge* or *wheelhouse*. The top of the wheelhouse is known as the housetop.

The *inner bottom* and *engine-room tank top* form a large, level space with heavy, strong construction. They are used as a base for machinery. This double-bottom space is used for storage of fresh water and, in some cases, for fuel-oil tanks. It also is a safety measure in case of damage to the bottom of the ship.

The *machinery space* is used for propulsion machinery as well as auxiliary lighting, generators, pumps, condensers, and all the other equipment necessary to operate a ship.

The *after peak* is used as a dry buoyancy space or as a ballast tank. Immediately above the after peak is the steering-gear flat where the steering machinery for the ship is located.

Between the upper deck and the *poop deck*, which is just above the upper deck at the after end of the ship, are quarters where the crews' rooms are located. There is an *after boat deck* which is above the poop deck, and here the lifeboats are located.

The *rudder* is at the stern of the ship just below the steering gear; it is used to steer the ship.

The *plimsoll marks*, or freeboard markings, designate the load water lines for different water and weather conditions, and are subject to regulations of insurance companies.

The *deck fittings* and *rigging*, such as smokestack, lifeboats, booms, davits, accommodation ladder, ensign staff, mainmast, topmast, forward masts, anchor windlass, and anchor locations can easily be noted by referring to Figs. 15 and 16. Descriptions will be found in the Appendix.

The *profile* of a cargo ship, when compared with the tanker, differs considerably. The double bottom extends from the after-peak bulkhead to the forepeak bulkhead. This space, which is under the tank top, is used for fresh water or fuel oil, or both.

In some cargo ships, the machinery space is located amidship so that when the ship is traveling light, balance can be maintained in the fore-and-aft direction. The machinery space on a tanker is not located amidship because this would necessitate the use of a shaft alley through the oil-carrying cargo tanks. On the cargo ship the shaft alley extends from the engine room through to the stern frame and propeller.

Cargo ships have several cargo holds to make easy the handling of cargo. No. 1 is the hold forward, No. 2 is the next one aft, etc. They are separated by watertight bulkheads. These holds are separated, or divided, by transverse bulkheads; and they are separated by different decks, the second deck just below the main deck and the third deck below the second. All of these decks are reached through the one hatch at the main deck and are used to separate and keep apart different types of cargo.

Layout of a Typical Tanker

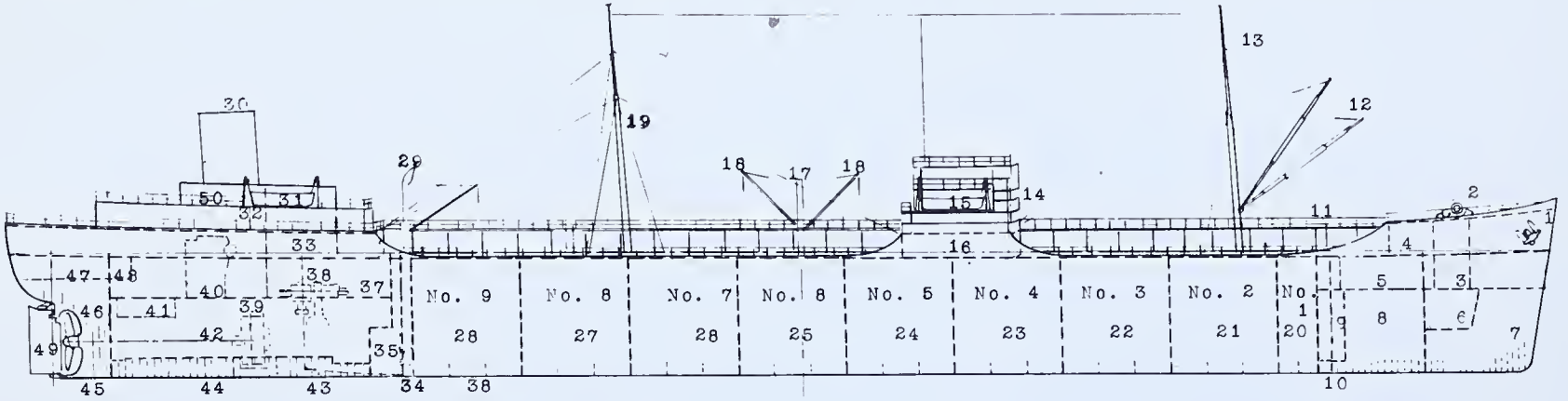


FIG. 14 — *Profile View of Tanker*

1. Ship's Anchor
2. Anchor Windlass
3. Chain Locker
4. Ammunition Trunk
5. Dry Cargo
6. Ammunition Chamber
7. Forepeak Tank
8. Deep Tank
9. Pump Room Forward
10. Cofferdams
11. Walkway or Catwalk
12. Ship's Cargo Booms
13. Foremast
14. Navigating Bridge and Quarters for Officers
15. Lifeboat
16. Fresh-water Tanks and Storage Place
17. King Post
18. Hose Boom (Booms for Lifting Hose to Make Fast —For Loading Cargo)
19. Mainmast
20. No. 1 Cargo Tank
21. No. 2 Cargo Tank
22. No. 3 Cargo Tank
23. No. 4 Cargo Tank
24. No. 5 Cargo Tank
25. No. 6 Cargo Tank
26. No. 7 Cargo Tank
27. No. 8 Cargo Tank
28. No. 9 Cargo Tank
29. Ventilator and King Post
30. Smokestack
31. Lifeboats
32. Quarters for Officers
33. Quarters
34. Cofferdams at Sides
35. Cargo Pump Room
36. Cargo Pump-Room Trunk
37. Fuel-oil Tanks
38. Turbogenerator
39. Main Propulsion Motor
40. Boiler
41. Distilled-water Tank
42. Propeller Shaft
43. Feed-water Tanks or Double-bottom Tanks
44. Feed-water Tanks or Double-bottom Tanks
45. Propeller
46. After-peak Tank
47. Steering Gear
48. Fresh-water Tank
49. Rudder
50. Fidley Deck

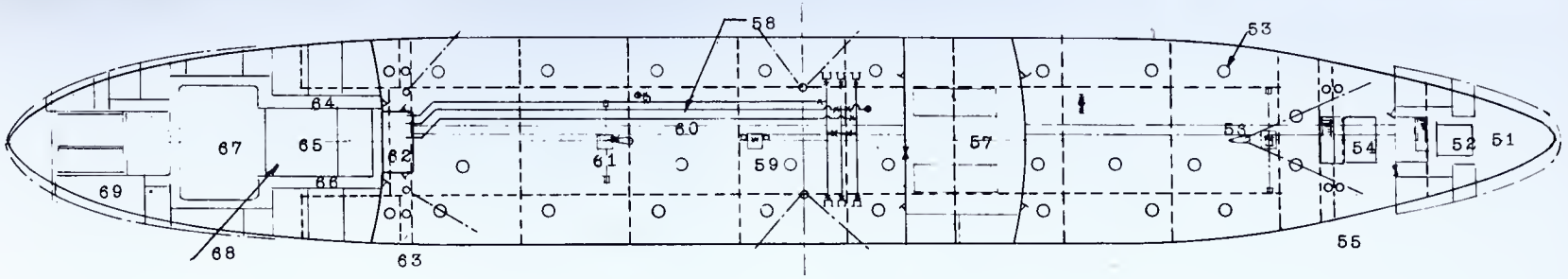


FIG. 15 — *Plan View of Tanker*

51. Forepeak
52. Anchor Windlass
53. Cargo-tank Covers
54. Dry-cargo Hatch
55. Cofferdam
56. King Post
57. Navigating Bridge and Quarters for Officers
58. Cargo Lines
59. Deck Winch
60. Catwalk
61. Cargo Winch
62. Pump Room
63. Fuel-oil Cofferdam
64. Port Passageway
65. Engine Room
66. Starboard Passageway
67. Boiler Room
68. After Quarters
69. Afterdeck

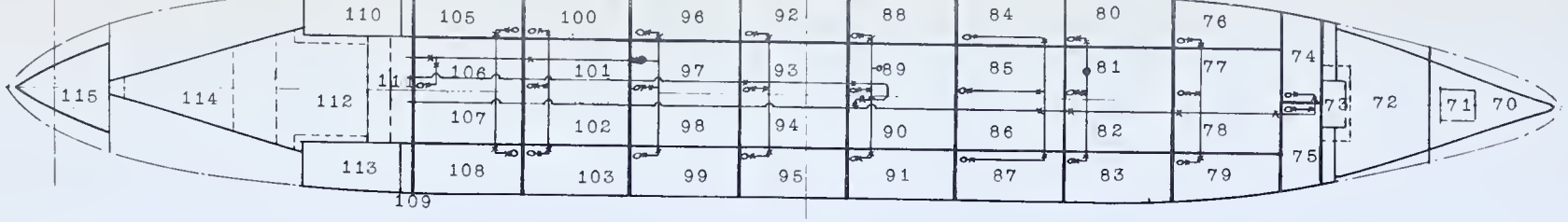


FIG. 16 — *Plan View Below the Upper Deck*

70. Bosun's Stores
71. Chain Locker
72. Deep Tank and Dry Cargo
73. Forward Pump Room
74. Cargo Tank No. 1 Port
75. Cargo Tank No. 1 Starboard
76. Cargo Tank No. 2 Port Wing Tank
77. Cargo Tank No. 2 Center Port Side
78. Cargo Tank No. 2 Center Starboard Side
79. Cargo Tank No. 2 Starboard Wing Tank
80. Cargo Tank No. 3 Port Wing Tank
81. Cargo Tank No. 3 Center Port Side
82. Cargo Tank No. 3 Center Starboard Side
83. Cargo Tank No. 3 Starboard Wing Tank
84. Cargo Tank No. 4 Port Wing Tank
85. Cargo Tank No. 4 Center Port Side
86. Cargo Tank No. 4 Center Starboard Side
87. Cargo Tank No. 4 Starboard Wing Tank
88. Cargo Tank No. 5 Port Wing Tank
89. Cargo Tank No. 5 Center Port Side
90. Cargo Tank No. 5 Center Starboard Side
91. Cargo Tank No. 5 Starboard Wing Tank
92. Cargo Tank No. 6 Port Wing Tank
93. Cargo Tank No. 6 Center Port Side
94. Cargo Tank No. 6 Center Starboard Side
95. Cargo Tank No. 6 Starboard Wing Tank
96. Cargo Tank No. 7 Port Wing Tank
97. Cargo Tank No. 7 Center Port Side
98. Cargo Tank No. 7 Center Starboard Side
99. Cargo Tank No. 7 Starboard Wing Tank
100. Cargo Tank No. 8 Port Wing Tank
101. Cargo Tank No. 8 Center Port Side
102. Cargo Tank No. 8 Center Starboard Side
103. Cargo Tank No. 8 Starboard Wing Tank
104. Cofferdam
105. Cargo Tank No. 9 Port Wing Tank
106. Cargo Tank No. 9 Center Port Side
107. Cargo Tank No. 9 Center Port Side
108. Cargo Tank No. 9 Starboard Wing Tank
109. Cofferdam
110. Fuel-oil Tank
111. Cargo Pump Room
112. Engine Room
113. Fuel-oil Tank
114. Shaft Alley and Machinery Space
115. After-peak Tank

Layout of a Typical Cargo Ship

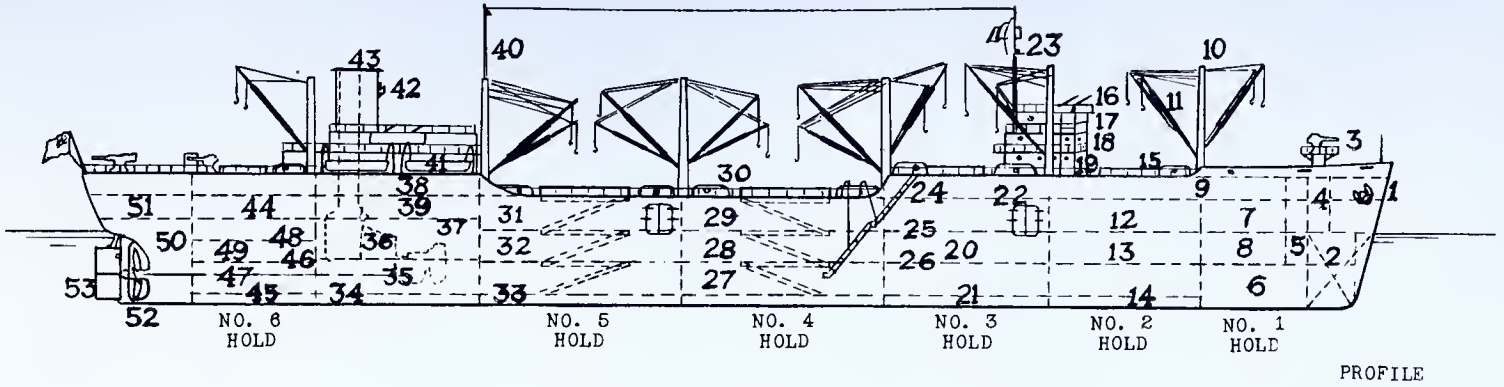


FIG. 17 — *Profile View of a Cargo Ship*

1. Anchor
2. Fore Peak Tank (Ballast)
3. Forward Gun Platform
4. Chain Locker
5. Ammunition Chamber
6. Deep Tank (Ballast)
7. No. 1 Upper 'Tween Decks
8. No. 1 Lower 'Tween Decks
9. Forecastle 'Tween Decks
10. Kingpost
11. Cargo Boom
12. No. 2 Upper 'Tween Decks
13. No. 2 Lower 'Tween Decks
14. No. 2 Double Bottom (Fuel Oil)
15. Handrail
16. House Top
17. Navigation Bridge
18. Bridge Deck
19. Officers' Quarters
20. No. 3 Lower 'Tween Decks
21. No. 3 Double Bottom (Fuel Oil)
22. Cargo Doors
23. Foremast
24. Companion Ladder
25. Second Deck
26. Third Deck
27. No. 4 Double Bottom
28. No. 4 Lower 'Tween Decks
29. No. 4 Upper 'Tween Decks
30. Cargo Winches
31. No. 5 Upper 'Tween Decks
32. No. 5 Lower 'Tween Decks
33. No. 5 Double Bottom (Fuel Oil)
34. No. 6 Double Bottom (Fresh Water)
35. Propelling Machinery Space
36. Distilled Water Tanks
37. Fresh Water Tanks
38. Accommodations
39. Accommodations and Commissary Mess
40. Main Topmast
41. Lifeboat
42. Whistle
43. Stack
44. No. 6 'Tween Decks
45. No. 7 Double Bottom Fresh Water
46. Fuel Oil Settling Tanks
47. Funnel Shaft
48. No. 6 Hold
49. Ammunition Chamber
50. After Peak Tank (Ballast)
51. Steering Gear
52. Propeller
53. Rudder

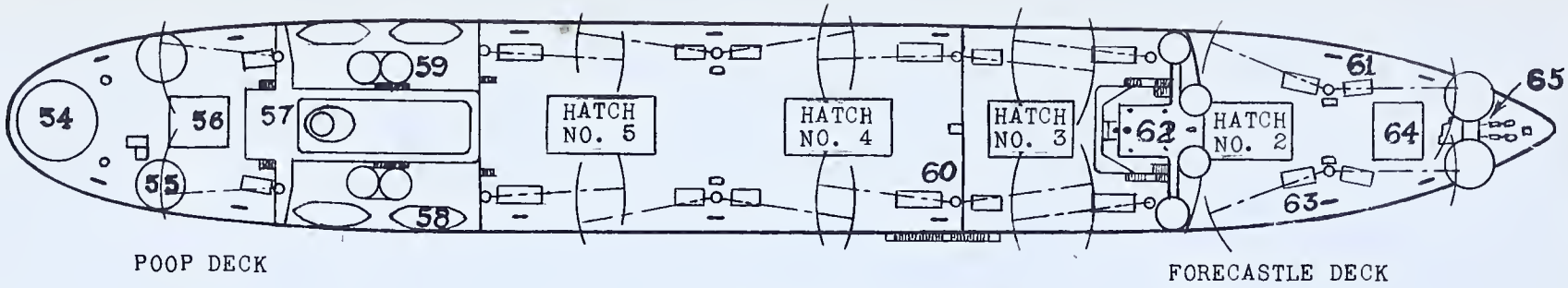


FIG. 18 — *Plan View of a Cargo Ship*

54. Stern Gun Platform
55. Gun Platform
56. No. 6 Cargo Hatch
57. Sky Lookout
58. Lifeboat
59. Gun Platform
60. Winch
61. Bridge
62. Bitt
63. King Post
64. No. 1 Hatch

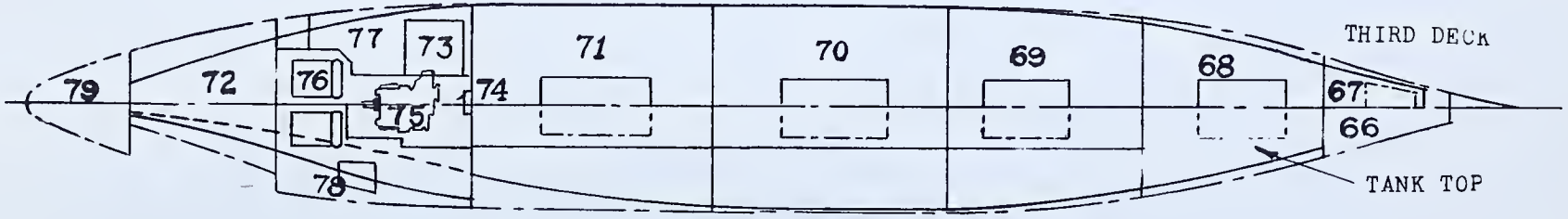


FIG. 19 — *Plan View Below Decks of a Cargo Ship*

65. Anchor Windlass
66. Deep Tank (Ballast)
67. No. 1 Lower 'Tween Decks
68. No. 2 Lower 'Tween Decks
69. No. 3 Lower 'Tween Decks
70. No. 4 Lower 'Tween Decks
71. No. 5 Lower 'Tween Decks
72. No. 6 Lower 'Tween Decks
73. Culinary Water Tanks
74. Escape and Service Trunk
75. Propulsion Machinery
76. Boiler
77. Lube Oil Tanks and Workshop
78. Fuel Oil Settling Tanks
79. After Peak Tank

QUESTIONS

1. How many tanks are found in a tanker?
2. Approximately where is the cargo-pump room located?
3. Why is the engine room located near the stern?
4. Of what use is the double bottom?
5. Where is most of the piping found in a ship?
6. Where are the cargo-pump valves located?
7. Are there any piping jobs to be found on the boat deck?
8. Cargo tanks have port wing, center, and starboard wing divisions. Are these divisions separated from each other?
9. Where are the longest straight runs of pipe located?
10. Where are the largest fresh water tanks located?
11. Most of the sanitary plumbing is located at two different places. Where are these spaces located and what are they called?
12. Is the boiler room located fore or aft of the engine room?

PART III
PIPEFITTERS' TOOLS

A. Tools That Each Pipefitter Is Expected to Own

1. Adjustable wrench
2. Set of box end wrenches
3. Square
4. Ball-peen hammer
5. 6-foot folding rule
6. 6″ steel rule
7. Architects' scale
8. Steel tape
9. Dividers
10. Plumb bob and line

B. Tools Found in the Pipe Shop Tool Crib

1. Stillson wrench
2. Monkey wrench
3. Open end wrench
4. Chain tongs
5. Parmalee wrench
6. Hack saws
7. Hand pipe cutters
8. Pipe reamers
9. Die stock and dies
10. Solid die and diestock
11. Armstrong die and diestock
12. Toledo dies and diestock
13. Nut die
14. Taps and tap wrenches
15. Cold chisels
16. Center punches
17. Drifts
18. Files
19. Extractors
20. Gasket punches
21. Trammels
22. Chalk lines
23. Flange spreaders
24. Rail straightener
25. Pipe vises
26. Chain jacks
27. Nipple chucks
28. Fox wedges
29. Soapstone
30. Screwdrivers

Pipefitters' Tools and Their Uses

General Information

A marine pipefitter must have a complete knowledge of the tools that he needs in order to do his work in an efficient and satisfactory manner.

A good pipefitter will always plan his work before he actually proceeds to do the job. He will also see that he has all the tools required to do the job before he begins his work.

The following is a descriptive list of the common tools that a marine pipefitter will use:

Stillson Wrench

Stillson wrenches are used almost entirely to screw pipes in or out of a coupling or other types of fitting. These wrenches may be used to get a grip on any cylindrical piece of material within the limits of the wrench opening. The jaws of the wrench have hardened teeth which grip the piece securely and prevent slipping. The teeth at the end of the handle are cut in a direction opposite to that of the teeth in the movable jaw; so the teeth grasp the pipe or fitting securely when pull is applied to the wrench. The jaws grip tightly only on the pull on the handle. Stillson wrenches are not to be used on finished surfaces or on a thermowell when installing a thermometer. Figure 20 shows the movable jaw and how, under the manipulation of an in-

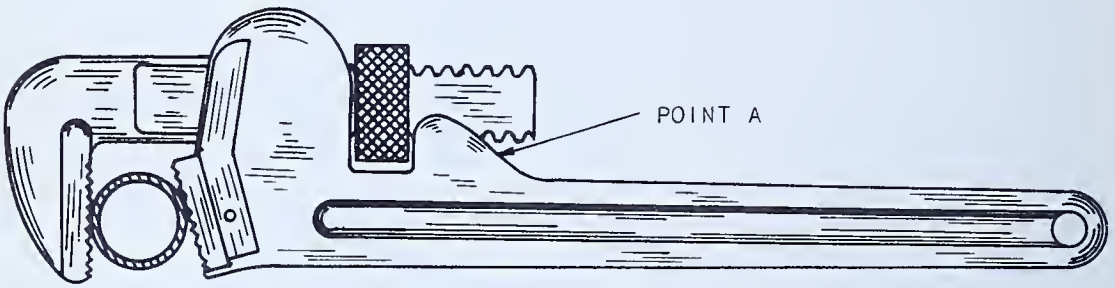


Fig. 20 — *Stillson Wrench*

ternally threaded collar, the jaw moves backward or forward through a carriage pivoted to the handle. The collar fits both the thread on the movable jaw and the opening in the carriage; so turning the collar adjusts the jaw to fit the pipe.

Another model of the Stillson wrench may be found in Fig. 21. This wrench has been found to be more useful and more efficient than earlier models. It has a small

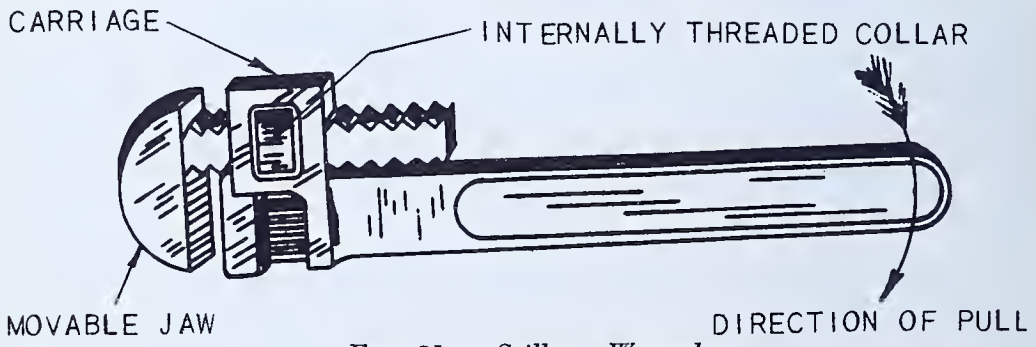


Fig. 21 — *Stillson Wrench*

spring in its construction *A* to hold a tension on the jaws of the wrench. The operator should be careful to keep his hand away from point *A* if pressure is to be exerted down on the movable head; the pressure is transferred through the carriage to the

heel of the jaw, and the hand may be pinched between the end of the jaw and the wrench handle. If the teeth are kept clean at all times, the wrench will not slip. Do not use a wrench as a hammer.

Stillson wrenches are made in many convenient sizes ranging from 6 inches to 48 inches in length. It is essential to use the correct size of wrench for each particular job. The size of the wrench to be used depends upon the size of the pipe. The following table shows the approximate size of wrench to be used on different sizes of pipe:

6″ or 8″ Wrench — used on pipe up to ¼ inch

10″ Wrench — used on pipe up to ⅜ and ½ inch

18″ Wrench — used on pipe up to ¾ and 1 inch

24″ Wrench — used on pipe up to 1½ and 2 inches

36″ Wrench — used on pipe up to 3 inches

48″ Wrench — used on pipe up to 4 inches

If a 10-inch wrench is used on a 1½-inch pipe, the amount of pull required to tighten the pipe would either break the 10-inch wrench or spring it out of shape. It is always better to have a wrench too large than too small. A word of warning may be given also in regard to using a large wrench. If the wrench is too large for the pipe size, the fitting into which the pipe is being screwed may be stretched or broken.

Chain Tongs

In order that pipes may be screwed tightly into fittings, it is necessary to employ some method or device that will grip and hold the pipe tightly and also allow the screwing force to be exerted at a distance from the center of the pipe.

Chain tongs, as shown in Fig. 5, *A* and *B*, are generally used for screwing up the larger sizes of pipe. Fig. 22 shows a cable chain at *A*, but either a flat-link chain

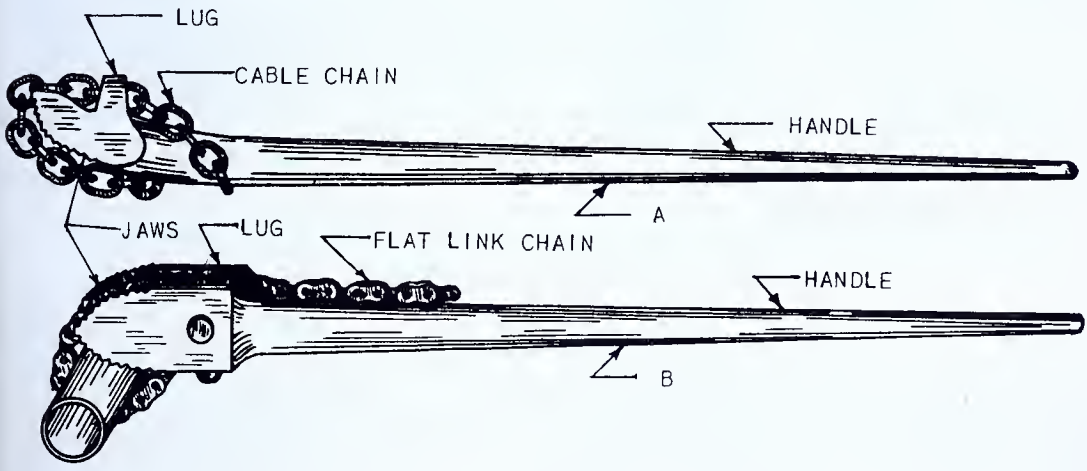


Fig. 22 — *Chain Tongs*

(Fig. 22 at *B*) or a cable chain may be used to do the job. The pipe tongs have serrated jaws at one end of a long handle. A chain is fastened to the lever near the jaws. When a pipe is to be tightened, the chain is passed around the pipe and drawn tightly. A link is dropped into a socket between a pair of lugs on the handle; the chain, thus secured, cannot slip, and so holds the jaws to the pipe. Pressure on the handle forces the jaws to bite into the pipe, and the pipe tongs will not slip if the chain has been fastened correctly. This type of tightening device can be used in close places where another type of wrench cannot be used.

The size of the pipe will determine the size of the chain tongs to be used.

Use the following size of chain tongs on the diameter of pipe listed:

2′ chain tong to be used on pipe 2″ to 2½″ in diameter
3′ chain tong to be used on pipe 2″ to 3″ in diameter
4′ chain tong to be used on pipe 3″ to 5″ in diameter
6′ chain tong to be used on pipe 5″ to 8″ in diameter
8′ chain tong to be used on pipe 8″ to 12″ in diameter

Parmalee Wrench

The Parmalee wrench, or friction wrench, is especially adapted for making up nickel-plated or polished brass pipe and finishing work around fixtures. It employs the same principles as the chain tongs. Instead of the chain and jaws of the chain tongs, there is a strap which is placed around the pipe. See Fig. 23. This hinged, straplike clamp (girth) has a frictional grip around the pipe which increases with the pressure exerted on the handle of the wrench. When installing the girth or strap,

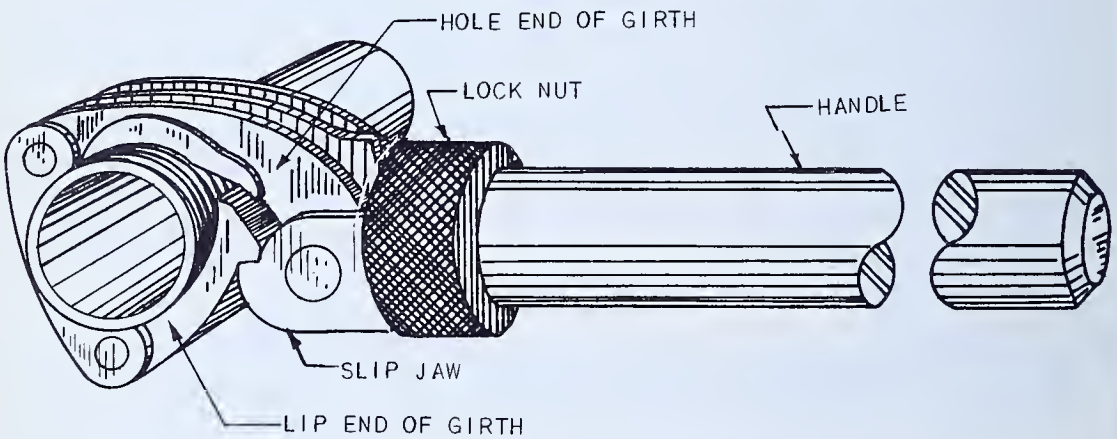


Fig. 23 — *Parmalee Wrench*

make sure that the hole-end is on top as shown in the figure. The strap clamp is wide enough to prevent crushing or marring the pipe. With these wrenches, powdered rosin is sometimes used to keep the wrench from slipping on the finished pipe. The rosin may be removed later with gasoline. In the pipe shop the usual size of Parmalee, or friction, wrench to be found is from ⅜ inch to 2 inches. A ⅜ inch Par-

malee wrench will tighten a ⅜-inch pipe. (This wrench is sometimes called knuckle wrench.)

A strap wrench is also a very handy tool for this work.

Open-End Wrenches

The name (open end) means that the wrench opening, which fits the nut, is cut out at the end of the wrench so that the wrench may be slipped on the nut (Fig. 24) from the side instead of setting the wrench down over the nut as is the case with a box or socket type of wrench.

The wrench may be applied and the nut turned down very rapidly with an open-end wrench, but care must be taken to use a wrench of the correct size. The size of the opening is usually stamped on the wrench. Open-end wrenches are of the single-end or double-end type, having different-sized openings at each end; the wrenches come in sets.

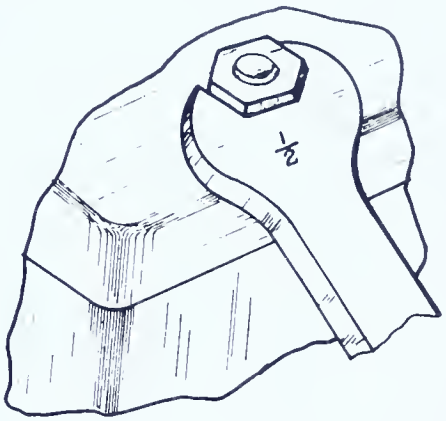


Fig. 24 — *Open End Wrench*

When too large a wrench is used, the corners of the nut are chewed off. Rounded corners make it difficult to get a nut off even with a wrench of the correct size. Wrench-opening sizes are always measured across the flat of a nut.

Open-end wrenches are designed to withstand a pull on the handle about equal to the same force that the bolt will withstand. Never use a hammer on an open-end wrench to tighten or loosen a nut. Use a pipe extension over the wrench handle to tighten the nut. When using a wrench near a solid object, do not wrap the fingers around the handle of the wrench. If the wrench should slip, the fingers may be smashed against the solid object. The palm of the hand should be used in order to keep the fingers free.

Adjustable Wrench

An adjustable wrench is used to a great advantage by the marine pipefitter in turning down nuts on flanges, etc. The adjustable wrench may be quickly changed by a thumb nut to fit many different nut sizes. See Fig. 25. Never use an adjustable

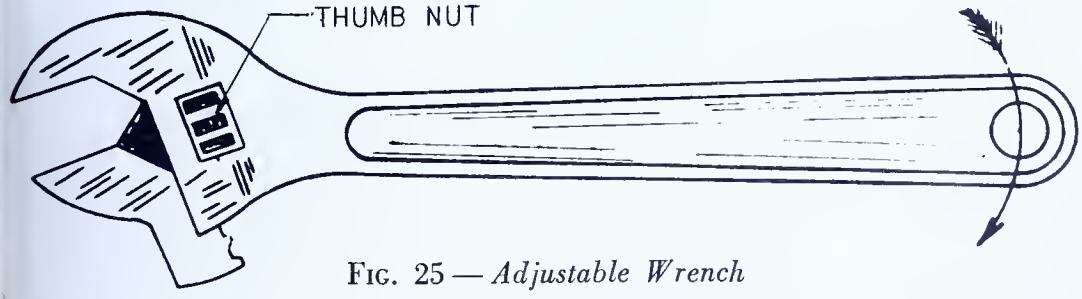


Fig. 25 — *Adjustable Wrench*

wrench as a hammer. Keep the adjusting nut and headless machine screw tight at all times. Use the correct size of adjustable wrench for the job. In putting strain on the wrench, pull in the direction shown in the figure if possible.

Box-End Wrench

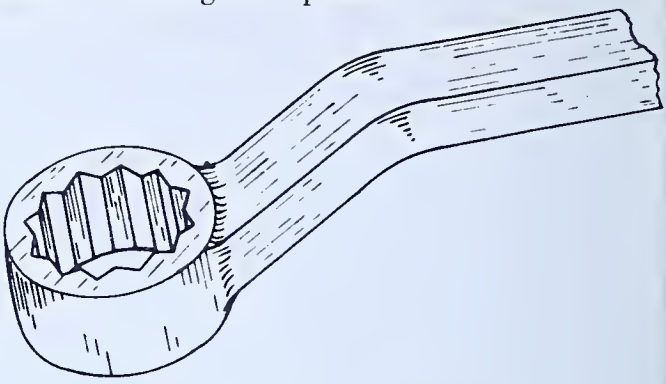


Fig. 26 — *Box Wrench*

The 12-point box wrench is a very important tool to use in cramped places. See Fig. 26. The illustration shows that the wrench may be placed on the nut in six different positions. A box wrench of this type may be used to tighten a nut where no other wrench can be used. Box wrenches come in many different sizes, the most common of which are those running from ½ inch to 1 inch.

Monkey Wrench

The monkey wrench is used for tightening pieces having hexagonal surfaces, such as hexagonal parts of brass valves and other similar fittings, without marring them. Refer to Fig. 27.

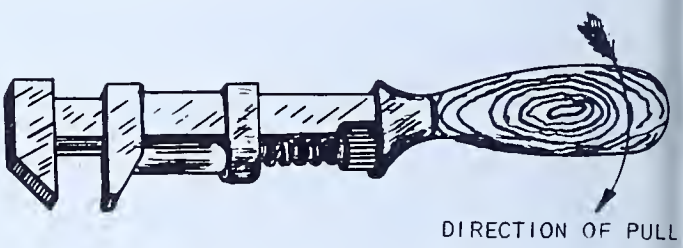


Fig. 27 — *Monkey Wrench*

The same wrench is used for screwing up bolts and nuts on pipe flanges. There are no teeth on the jaws, and the wrench may be used to exert pressure in either direction without reversing the wrench on the work. However, a monkey wrench will always hold to the work better when the direction of the pull is away from the back of the wrench. Pulling the other way has a tendency to spring the jaws open and cause the wrench to slip. In the pipe shop, the wrenches will not be less than 10 to 12 inches in size.

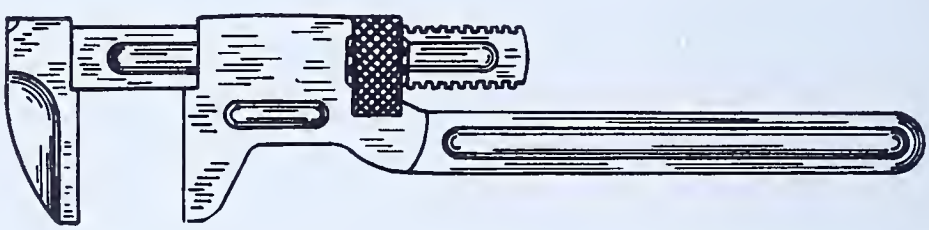


Fig. 28 — *Trimo Monkey Wrench*

Fig. 28 shows a Trimo monkey wrench, which was designed especially for the use of pipefitters and plumbers.

It is essential to remember that the jaws must be kept tight against the material on which the work is being done; otherwise the corners of the nuts or fittings will be marred, and the wrench jaws will eventually become loose.

Hack Saws

The hack saw is one of the pipefitter's most important tools. The frame of the hack saw is made adjustable to take blades of 8, 10, 12, and 14 inches in length. In the pipe shop a 12-inch blade is usually the length used. The teeth are spaced fine and coarse and are designated according to the number of teeth per inch. The two types of frames commonly used are the pistol-grip type, shown in Fig. 29, and the straight-handle type, Fig. 30.

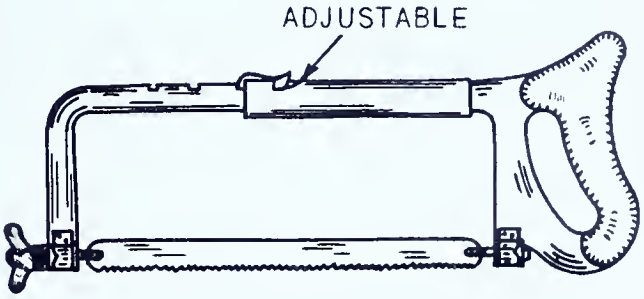


Fig. 29 — *Pistol-Grip Hack Saw*

The saws are mounted on pins in sliding studs on each end of the frame. Sliding studs provide a means of setting the saw blade to cut with the frame in any one of four positions. With the straight-handle type, the tension is applied to the blade by turning the handle and on the pistol-grip type of saw by turning a wing nut.

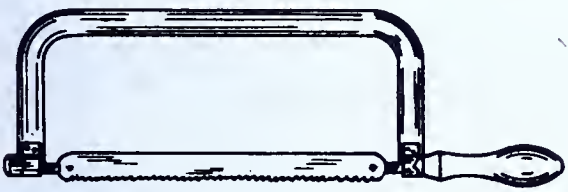


Fig. 30 — *Straight-Handle Hack Saw*

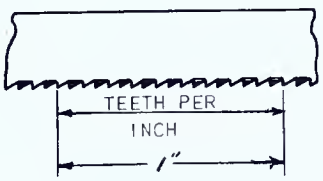


Fig. 31 — *Pitch*

The pipefitter uses the hack saw to cut templates and all smaller sizes of tubing and pipe to the correct lengths.

The pitch (teeth per inch), Fig. 31, is an important consideration when selecting a blade for the class of material to be cut. See Fig. 32. The greatest economy of time and materials is obtained by selecting the correct pitch of blade for the job. In the pipe shop the blade with 18 teeth per inch is recommended for general work.

SELECTING A HACK SAW OF CORRECT PITCH

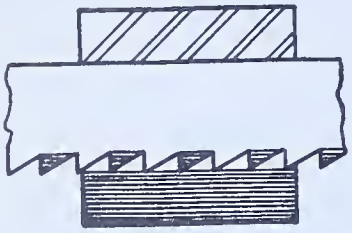
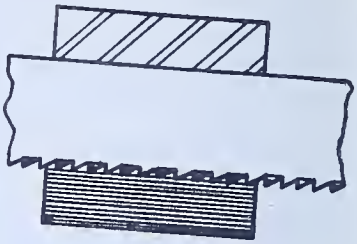
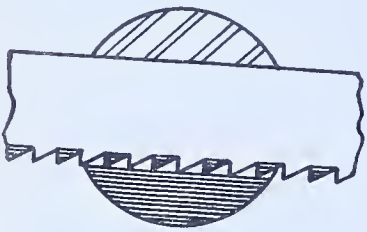
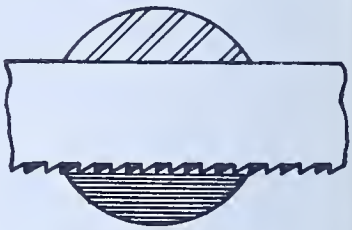
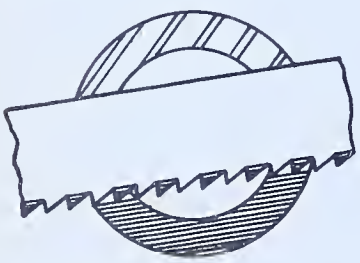
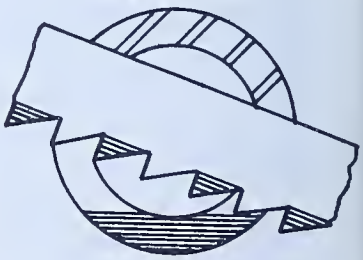
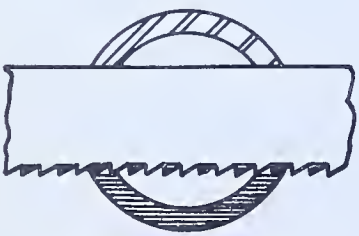
CORRECT		INCORRECT
	14 Teeth per inch. For mild materials and large sections.	
Correct chip clearance		**Lack of chip clearance— Teeth clogged— Pitch too fine**
	18 Teeth per inch. For tool steel, high-carbon, and high-speed steel.	
Correct chip clearance		**Lack of chip clearance— Teeth clogged— Pitch too fine**
	24 Teeth per inch. For iron pipe, angle iron, brass, copper, etc.	
At least two teeth on a section		**Pitch too coarse— One tooth on a section results in stripped teeth**
	32 Teeth per inch. For tubing, conduit, and sheet metal.	
At least two teeth on a section		**Pitch too coarse— Straddles work**

FIG. 32

A list of important factors to keep in mind while hack sawing:

1. Keep the blade under the correct tension. In order to avoid breaking blades in the first use of the hack saw, ask the leader how to adjust the tension. He will help you.
2. Hold the saw straight across the work and make even strokes from toe to heel.
3. Do not bear down too much. Too much pressure will either "strip" the teeth or "bow" the blade until it breaks.
4. Ease up slightly on the return stroke. The work is done on the "push" stroke.
5. When sawing thin stock or tubing, use a fine-toothed saw.
6. Coarse-toothed saws are better for soft stock or wide material. Fine-toothed saws plug up in soft material.
7. Do not allow the saw to "bind" in the cut. Follow a vertical line when sawing downward. If the saw is not held "easy" in the cut, the blade is easily broken.
8. Insert the saw with the teeth pointing forward.

Hand Pipe Cutters

Types of hand pipe cutters found in the pipe shop are multiple cutters for large pipe, cutters having two rollers and one cutter, and others with three cutters.

One type of three-wheel pipe cutter is shown in Fig. 33. Two hardened and tempered wheels are carried on pins in the cutter jaw and are free to rotate.

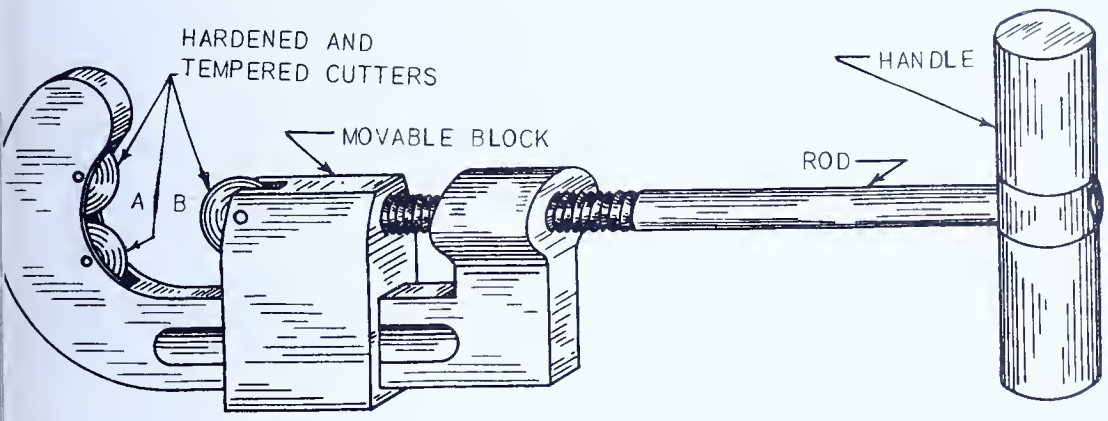


Fig. 33 — *Pipe Cutter*

Another cutting wheel is located in a movable block and is forced in toward the other wheels by turning the handle. The pipe to be cut fits between the cutting wheels *A* and *B*. The handle on the screw is then turned and the cutter is rotated around the entire pipe. The sharp cutting wheels cut a groove in the outside surface of the pipe, and the groove is made deeper by a continual turning of the handle. When the pipe is nearly cut through, it may be broken off. When pipe is be[illegible]ut at a work bench, a single-wheel cutter is frequently used. The cutting wheels *A* in the cutter jaw are replaced by two smooth rollers which help to make a true and even hold on

the pipe and eliminate a burr that forms on the outside of the cut. See Fig. 34. If a three-wheel cutter is not held squarely with the pipe, it will cut several grooves instead of one. The difficulty is not apparent when using a single-wheel tool; the single-wheel tool, however, does not cut the pipe so quickly as the three-wheel cutter.

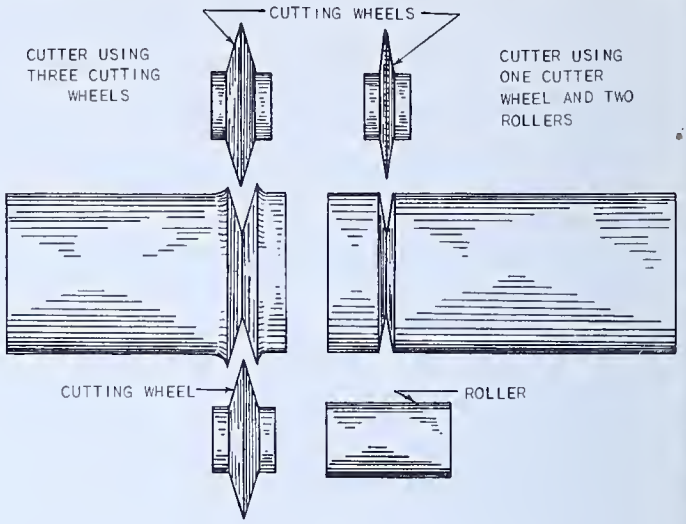


FIG. 34 — *Cutting Wheels and Rollers*

Oil should be used freely in cutting pipe, and the edges of the cutting wheels should be kept sharp; if they become dull, they will tend to force the pipe inward and cause an internal burr which will reduce the size of the pipe. This will restrict the flow of the liquid within the pipe. Even sharp wheels will leave a burr. After the pipe has been cut, a reamer should be employed to remove all burrs.

PIPE REAMERS

After a piece of pipe has been cut, the internal burrs should be removed. Burrs are removed by reaming the pipe with a tool called a pipe reamer. Reaming helps to reduce the friction and resistance that may otherwise cause trouble after the piping job is in operation. This tool is cone-shaped and has very sharp edges or blades. When the cone is pressed into the pipe and revolved, the blades cut off the burr and give a smooth cone-shaped form to the internal surface of the opening. A hand ratchet reamer is shown in Fig. 35. The cutter blades of the ratchet reamer are usually cast solidly in the head and are made of high-speed steel. The cutting teeth can easily be resharpened, or the reamer head can be replaced if necessary. Pipe reamers of various sizes ($\frac{1}{8}$" to 3") may be found available for pipefitting use.

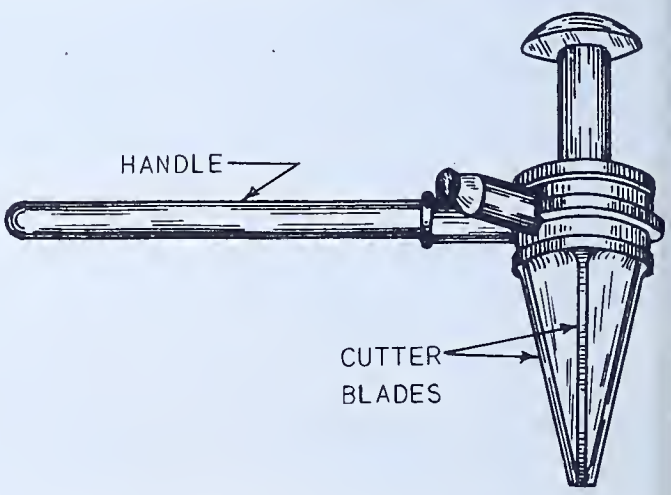


FIG. 35 — *Ratchet Pipe Reamers*

Die Stocks and Dies

The procedure of cutting a thread on the outside of a round piece of material is called threading. In pipefitting, the threading is done after the pipe has been cut into the correct lengths. Pipes are threaded by means of tools called stocks and dies. There are many different sizes and shapes of stocks and dies. It must always be remembered that good results in threading any type of metal are obtained only when the dies are made to cut and not to push. A die that pushes the metal instead of cutting it will soon break the threads in the die.

Hand threading dies are used to cut threads on bolts, screws, pipe, and other work that does not require precision threading. Some dies are made solid and have a fixed size, while others are split on one side to allow for adjustment; still others are made like chasers and held in a guide.

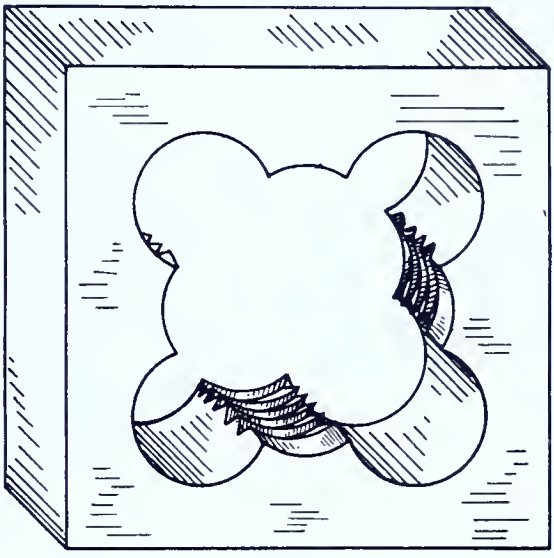


Fig. 36 — *Solid Die*

Solid Die and Die Stock

One type of die is the square die which is not adjustable. These dies are very useful for recutting a damaged or burred thread. See Fig. 36. This type of die fits in an ordinary die stock employed in threading small pipe by hand. The stock consists of an iron frame or body that holds the die. A handle is screwed into each side for turning the stock around the pipe. The die is placed in a recess and fastened with a cover as shown in Fig. 37. The part of the stock that is slipped over the end of the pipe to be threaded has a guide that holds the pipe rigidly by means

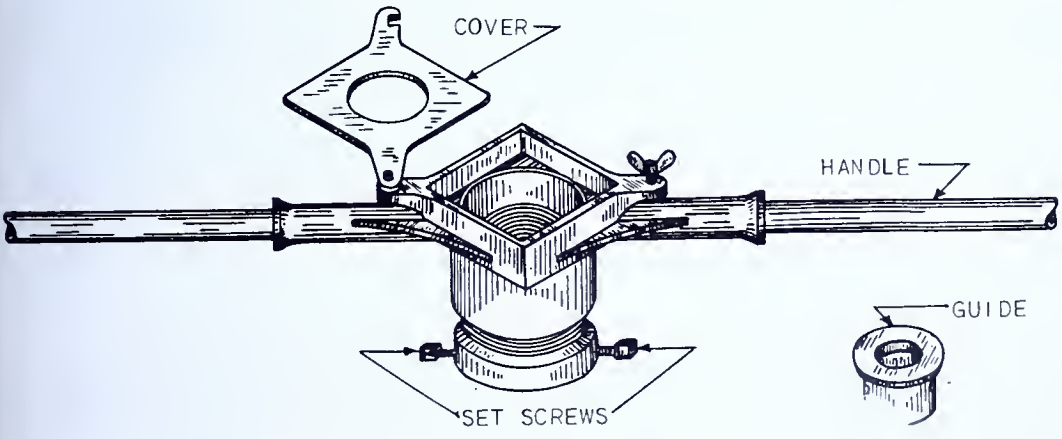


Fig. 37 — *Die Stock*

of set screws. The set screws keep the guide from turning or falling out while the pipe is being threaded. A solid die can cut a thread equal only to its own diameter, which means that there must be a different size of tap used for each size wanted. It may also be said that solid dies cannot be sharpened so easily as adjustable dies.

Armstrong Die Stock and Dies

Another type is the Armstrong die stock and adjustable dies. It consists of a solid stock, or casting, machined to hold a set of dies and two handles. It also has a bushing, or thimble, for centering the pipe and guiding the dies. Two set screws hold the

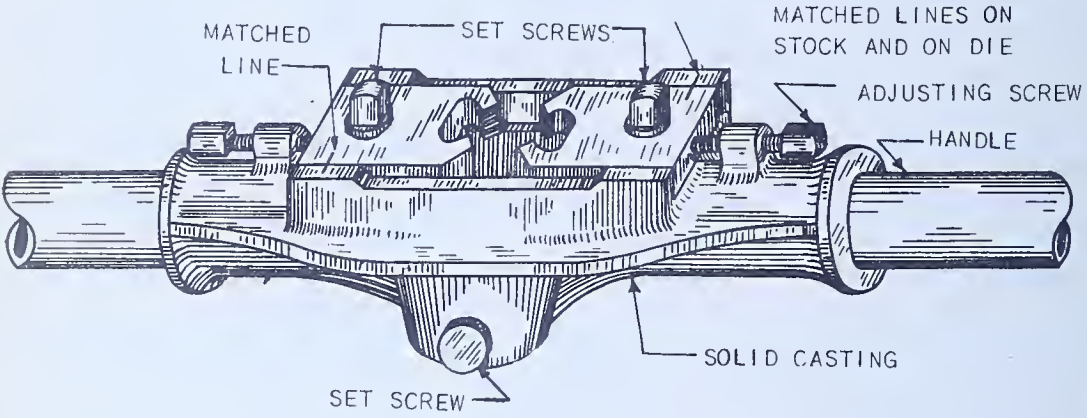


Fig. 38 — *Armstrong Stock and Dies*

dies in place. Lines are cut in the stock, and corresponding lines are cut in the dies so that when the lines are matched (die and stock), the dies are set to cut a standard size of thread. See Fig. 38 for markings.

Located in the rear of the stock is a guide which has an opening to allow a round, washer-shaped piece of metal to enter. The hole in the pipe guide is just large enough to permit the size of pipe that is to be threaded to pass through. If the pipe guide were not used, the result would be crooked threads on the pipe or failure to cut threads at all.

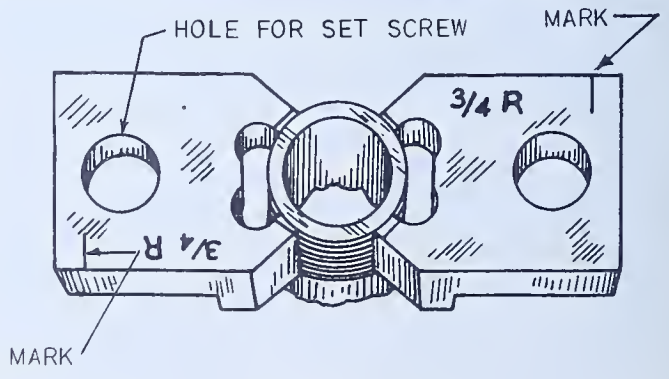


Fig. 39 — *Dies*

The die for the Armstrong die stock is a solid piece of tool steel with machined teeth and a hole cut in the center to enable the set screw to go through the die, enter the stock, and hold the die solidly when ready for use. See Fig. 39. Armstrong stock Number 1 will take dies from $\frac{1}{8}$″ to $\frac{3}{8}$″, Number 2 will take dies from $\frac{1}{2}$″ to 1″, and Number 3 will take dies from $1\frac{1}{4}$″ to 2″.

Toledo Die Stock and Dies

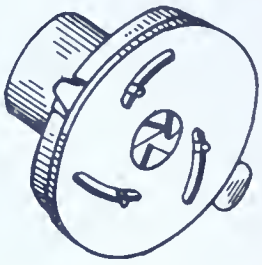


Fig. 40 — *Adjustable Rings*

The Toledo stocks and dies are also used to a great extent by the marine pipefitter. The construction of the Toledo stocks and dies is entirely different from the Armstrong type. The stock consists of a round casting machined to hold the dies. The dies are made to fit into slots in an adjustable ring that pushes the dies backward or forward depending on the size of pipe to be threaded. See Fig. 40. Handles also are screwed into each side of the casting. Unlike other types of hand threading devices, this tool will cut several different sizes of pipe threads with the same dies. The small-sized stocks will cut from $\frac{1}{8}$″ to $\frac{3}{4}$″ without changing dies other than making adjustments for each size.

The face of the adjusting ring is marked with witness marks which match corresponding witness marks on the stock. By moving this ring backward or forward to the different marks, the dies may be set to cut a perfect thread for the size wanted. The next set of Toledo stock and dies will cut threads from 1″ to 2″, etc.

Several types of Toledo adjustable pipe-threading tools are shown in Fig. 41. Larger sizes of pipe may also be threaded by using a Toledo stock and dies.

A ratchet stock becomes a very handy tool for threading the ends of a pipe where it is impossible to swing a common type of stock, such as threading a pipe close to

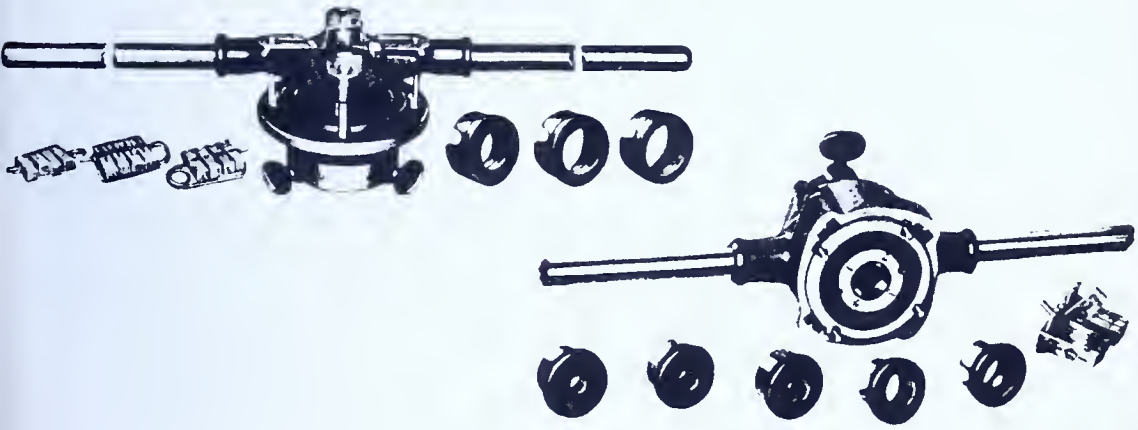


Fig. 41 — **Toledo Adjustable Pipe-Threading Tools*

the deck or bulkhead. A Toledo ratchet stock and dies are shown in Fig. 42. The handle of the stock screws into a socket in the body and turns the stock and die.

The dies are of different sizes to fit pipes of several different diameters. The shank of each is formed into a ratchet. When the die head is slipped into the body opening, the pawl engages the ratchet. Refer to the figure. When the handle is moved back and forth, the die is turned and a thread is cut. It must be remembered that plenty

*Courtesy of the Toledo Pipe-Threading Machine Co.

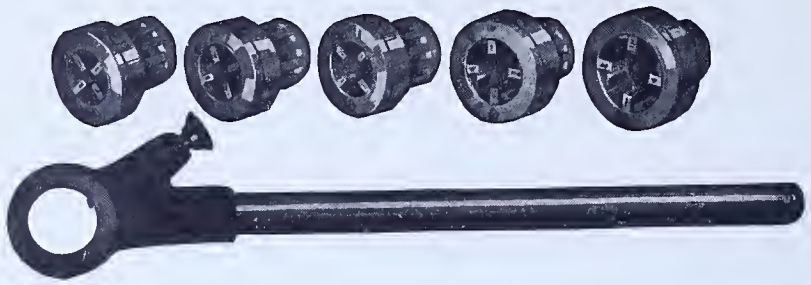


FIG. 42 — *Ratchet Pipe-Threading Tool*

of oil must be used to do a good thread-cutting job. Always clean the teeth of the die before attempting to cut a thread.

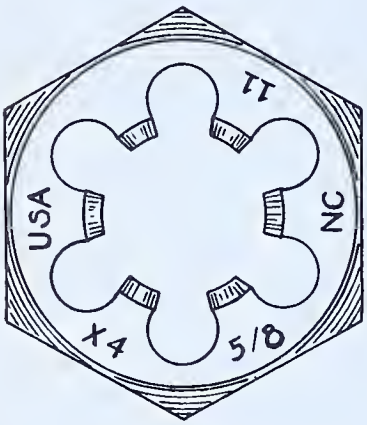


FIG. 43 — *Nut Die*

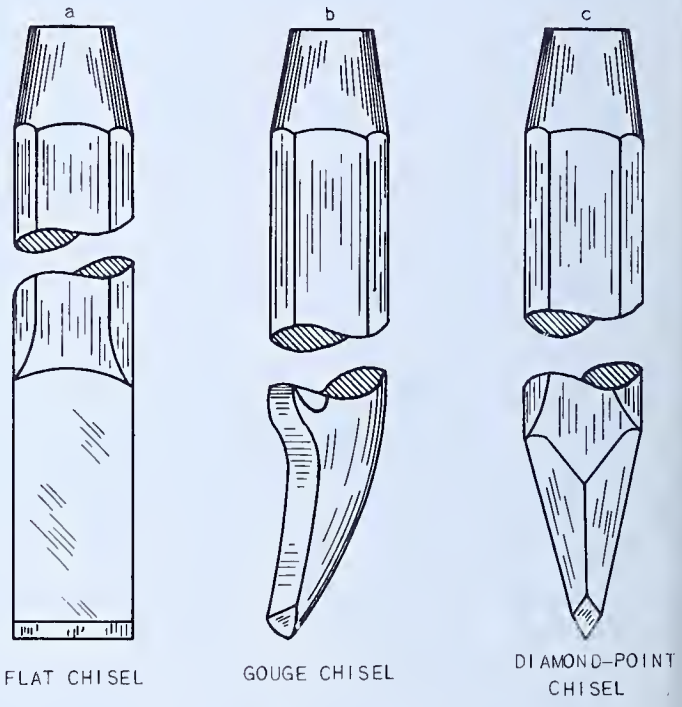


FIG. 44 — *Cold Chisels*

NUT DIE

The nut die is a handy tool to fix broken, burred, or smashed threads on bolts and studs. It is hexagon-shaped and fits into an open-end wrench or a box wrench. It is very similar in appearance to the common hexagonal nut, but instead of regular threads it has a set of sharp cutting teeth the same as a regular, solid type of die. The nut die (Fig. 43) is used in close places and is turned with a wrench.

COLD CHISELS

Cold chisels are frequently used by the pipefitter to cut off pipe protruding through a flange, to remove broken nipples, to cut off rusted bolts, etc. The types of chisels most frequently used are the flat chisel, the gouge chisel, and the diamond-point chisel. See Fig. 44.

The flat chisel, Fig. 44 at *a*, is used primarily for chipping rough spots off flat surfaces, chipping burrs, smoothing edges, and cutting off pipe and rusted nuts.

The gouge chisel, sometimes called a round-nose chisel, Fig. 44 at *b*, is used for roughing out round corners, cutting oil grooves, drawing a drill to center, and removing broken threads in fittings and flanges.

The diamond-point chisel, Fig. 44 at *c*, is adapted for cutting V-shaped grooves, chipping out rough spots in square corners, removing broken nipples, etc. It is used on the smaller sizes of pipe and fittings.

All steel is not suitable for making cold chisels. As a chisel must withstand repeated, heavy blows, it is not practical to harden the whole tool. After the chisel (material being .75 to .85 carbon steel) is dressed the cutting edge is tempered and ground to the desired angle. The temper extends about ¾ inch from the edge. Flat cold chisels are ground on opposite sides making a 70-degree angle. The stock used is generally octagonal in shape, but round stock is often used.

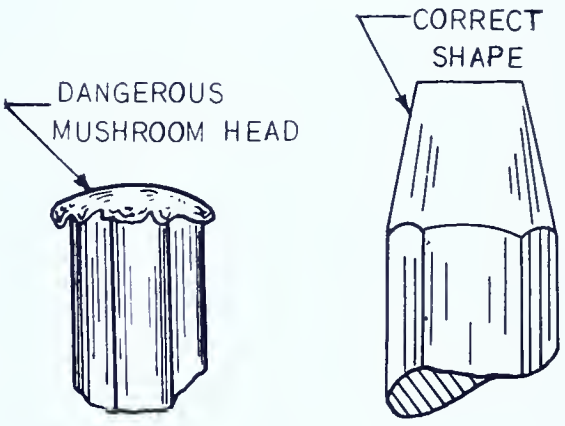


FIG. 45 — *Correct Shape of Chisel Head*

Mushrooming of the top of the chisel will result from ordinary use. Keep the mushroom down to a minimum by grinding before it spalls off and hurts someone. See Fig. 45 for correct shape of head. Be careful to chip away from anyone working near. Use goggles when chipping.

FILES

The marine pipefitter frequently makes use of files to smooth down the ridges left by hand pipe cutters, rough ends left by the burner, ragged cuts on a line made by the burner for fittings, rough flange faces, and battered starting threads. The files most commonly used by the fitters are the half-round, the round, and the flat files. The half-round file is generally used on pipe because the round part, which is a segment of a circle, can be inserted into the pipe for removing burrs, etc., while the flat part of the file can be used on the outside.

There are a great many types and sizes of files available, but the pipefitter comes in contact with only a few of them. Fig. 46 shows a cross section of five different files. The cross-section dimensions will vary in proportion to the length of the file,

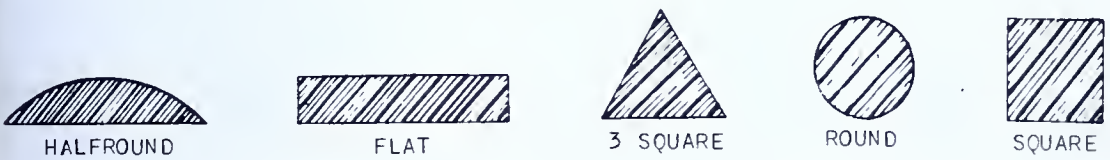


FIG. 46 — *Shapes of Common Files*

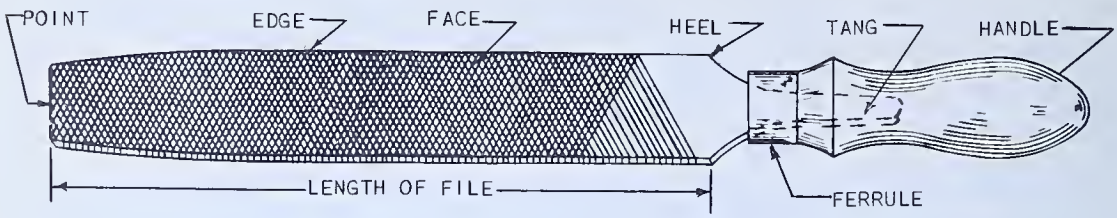


FIG. 47 — *Parts of a File*

but the shape remains the same. The length of the file is taken from the heel to the point as shown in Fig. 47.

When a piece of pipe is being filed, the body should not be kept rigid but in a position that allows a free and easy motion in the direction in which the file is moving. If the pipefitter is right-handed, the left foot should be toward the work, and as the file is moved forward, a slight bending of the left knee will tend to throw the body against the file and thus aid in making the cut. With the return stroke, the knee is straightened as the body returns.

A sharp chisel-edged, hardened tool in a special machine cuts the teeth on a file before the file is hardened. Figure 49 shows magnified surfaces of a bastard file and second-cut file.

The names of the cuts indicate the spacings of the teeth rows. A bastard file has teeth spaced farther apart than a second-cut. The term "second cut" means there are two rows of teeth in about the same distance as one row of teeth on a bastard file. The second-cut file is a finer file than a bastard, but not so fine as a mill file.

Both the files named above are "double-cut" which means that there are two rows of cuts or teeth on the full length of the file. Look at the point or the heel of a file, and it is quickly discovered whether the file is "single" or "double" cut. See Fig. 49 for single-cut and double-cut files.

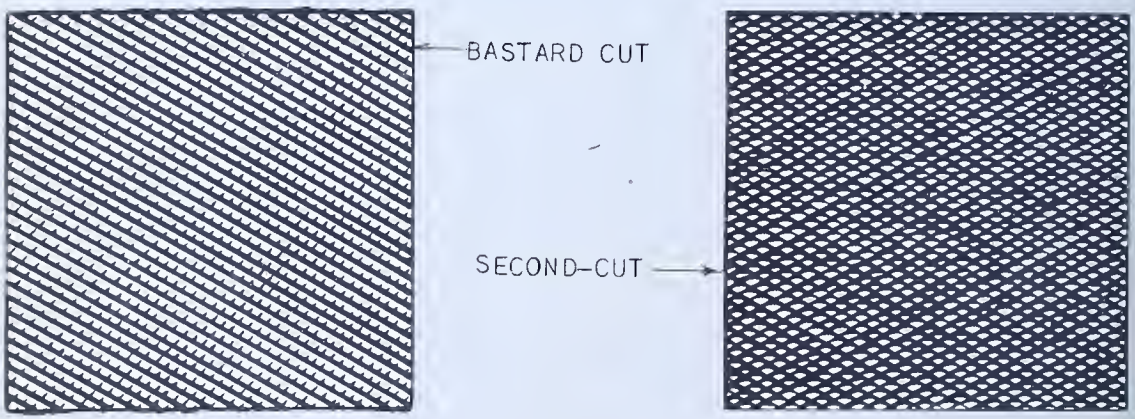


FIG. 48 — *File Surfaces*

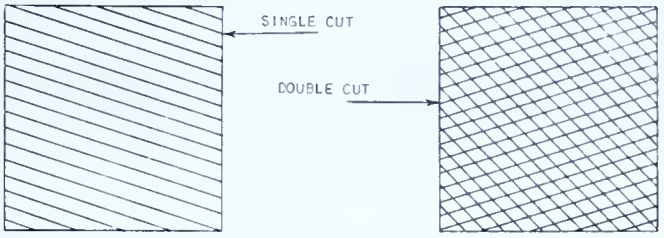


FIG. 49 — *File "Cuts"*

Files should never be thrown on one another, on the deck, or on other tools. Files are hardened; consequently they are brittle. Keep the file clean on the job. When a file "pins" (becomes choked with filings), clean it with a file brush. Use a file handle at all times and see that the handle fits snugly. Do not use a split handle or a handle without a ferrule. Pounding on a file should be avoided.

TAPS AND TAP WRENCHES

A hand tap is a small tool used for cutting internal threads for bolts. The tap is accurately threaded and grooved. The grooves, or "flutes", are milled the length of the threaded portion to form a series of cutting edges.

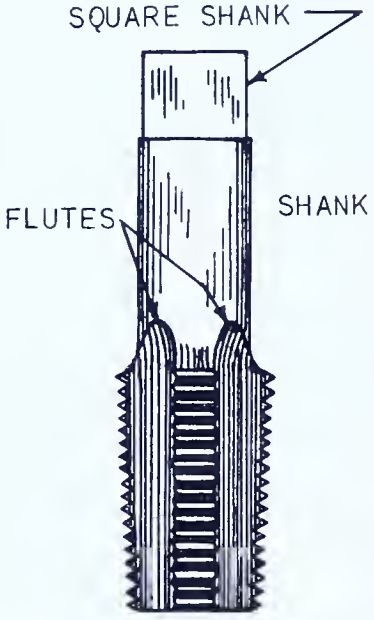


FIG. 50 — *Pipe Tap*

As a rule, the only taps used by pipefitters are the pipe taps and the machinist's hand taps. A common pipe tap is shown in Fig. 50. The threads of a pipe tap are tapered to conform to standard pipe threads. The flutes, which expose the cutting edge, also provide a means of letting the cuttings escape. The standard taper for the threaded portion of a pipe tap is 1/16 inch to the inch.

The machinist's hand taps are also very useful to the pipefitter for tapping or retapping holes for studs and machine screws. A full set of hand taps includes three taps. (Fig. 51).

1. Taper taps (tapered for four or six threads)
2. Plug taps (tapered for three or four threads)
3. Bottoming taps (the corners of the leading thread are chamfered)

When a hole has been drilled through a piece of metal (deck tank, etc.), use only a taper tap. It has room to pass through the work and cut a full thread. When the hole is drilled partly through the work to be threaded, it is sometimes necessary to use all three taps. See Fig. 52. The thread is started by using a taper tap until it touches the bottom of the hole. The plug tap is used next, and finally the bottoming tap cuts thread to the bottom of the hole.

It is very important to have a hole or a pipe tapped squarely; it is essential to put oil on the threads, place in the hole to be tapped, and give several turns with a

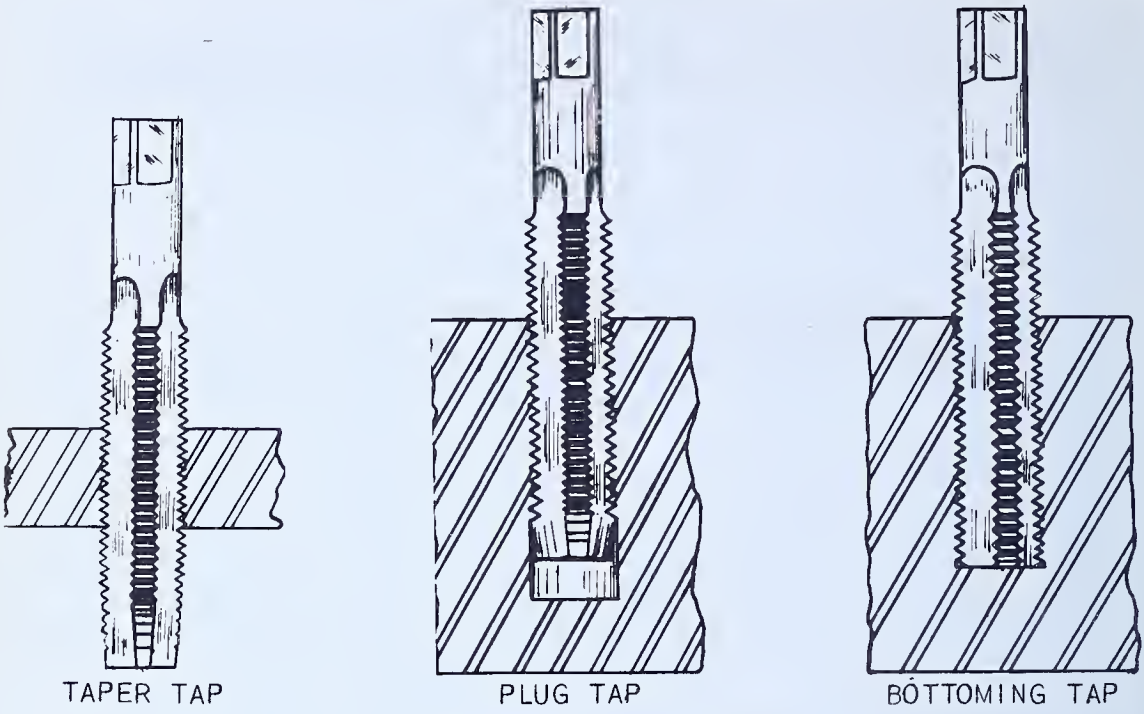


FIG. 51 — *Types of Taps*

wrench. A square may be used to check the tap (Fig. 53) to see that it is started correctly, or "sighting" the tap may serve to show that it is perpendicular to the surface of the work or parallel to the pipe (if tapping a piece of pipe).

Tap wrenches are made in a number of types and sizes. Figure 54 at *A* shows a double-ended, adjustable tap wrench which permits the use of various sizes of taps. Other types include the solid tap wrench with a fixed size of hole for the tap and a

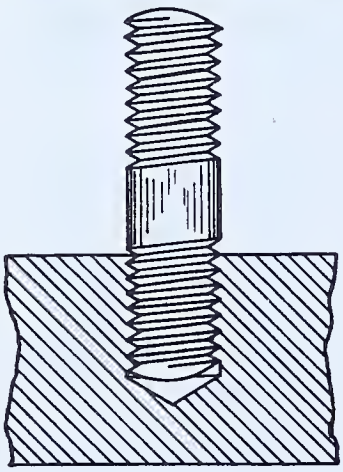


FIG. 52 — *Hole Drilled Partly Through a Piece of Metal*

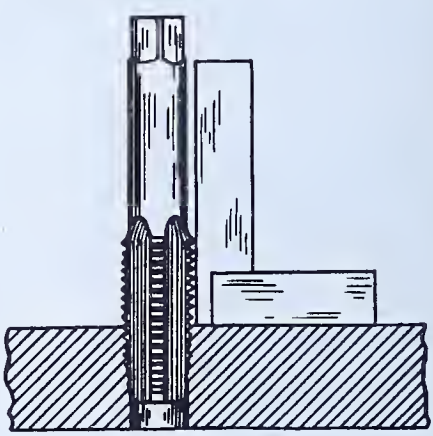


FIG. 53 — *Tapping a Hole Drilled Through a Piece of Metal*

A DOUBLE HANDLED ADJUSTABLE TAP WRENCH

B SINGLE HANDLE NON-ADJUSTABLE TAP WRENCH

FIG. 54 — *Types of Tap Wrenches*

T-handled wrench which has adjustable jaws. A wrench may also be used to turn a tap in places where a double-handed wrench cannot be used. The most commonly used tap wrench found in the pipe shop is a single-handled, non-adjustable type. Each size of tap requires a tap wrench to fit the size of shank on the tap. See Fig. 54 at *B*.

PIPE VISES

A pipe vise is used for holding a piece of pipe rigid while it is being cut and threaded, or while fittings are being screwed on the pipe. Perhaps the most commonly used pipe vise is the hinged pipe vise as shown in Fig. 55. The pipe is gripped

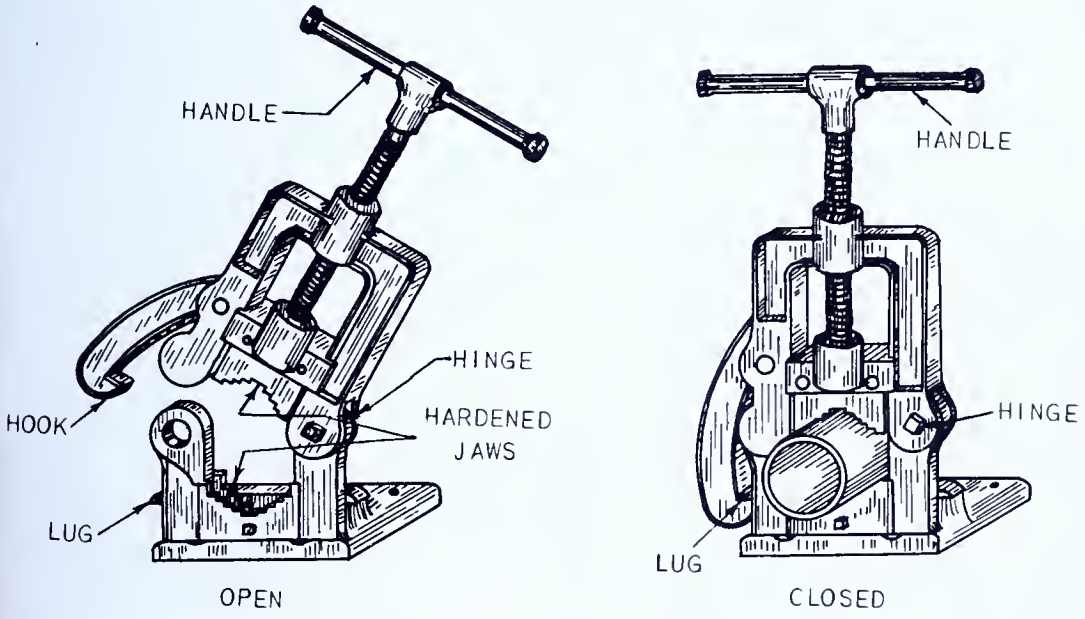


FIG. 55 — *Pipe Vise*

by the teeth of the hardened jaws. The vise is shown in an open position, having the upper part of the frame swung up around the center which forms a hinge. When a piece of pipe is in the vise, the upper part is swung down and secured by a hook which engages the lug. The pipe is gripped by screwing the jaw firmly down on the pipe. It is well to remember that the teeth of the pipe vise should be kept sharp or they will slip and cut a furrow around the pipe. The furrow will mar and weaken the pipe.

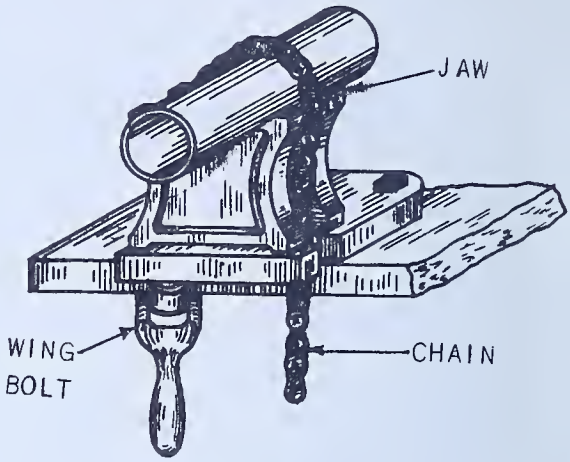


FIG. 56 — *Chain Vise*

Other types of pipe vises may be found in pipefitting shops. The combination pipe and vise is constructed so that it can be attached to a work bench wherever it is convenient to hold pipe for cutting threads or screwing on fittings. The vise may be used as a machinist's vise or for work other than holding pipe. The chain pipe vise is used to hold pieces of pipe or fittings. It is convenient and quickly operated. See Fig. 39. The pipe is laid on the jaw of the vise, and the chain is drawn tightly around the pipe to hold it fast with a wing bolt. This type of vise is particularly adapted to holding fittings. See Fig. 56.

BALL-PEEN HAMMER

The ball-peen hammer may be used for many things by the marine pipefitter. It may be used for making center-punch marks, driving wedges, driving pins in and out, cutting holes in gaskets, marking gaskets, chipping with a cold chisel, pounding rolled flanges, etc. The use of a bolt, a bar of steel, or any other makeshift should never be considered. Always use a hammer to do these jobs.

A careful study of a hammer handle will show that it is evenly balanced in the head. The length of the handle may vary to suit the individual. A handle that does not fit the hand well is apt to tire or cramp the hand when it is used continuously. When using a hammer, the workman should always grasp the handle close to the outer end and not at the head end. Holding the hammer close to the head is called "choking the hammer" It is a bad practice and causes accidents.

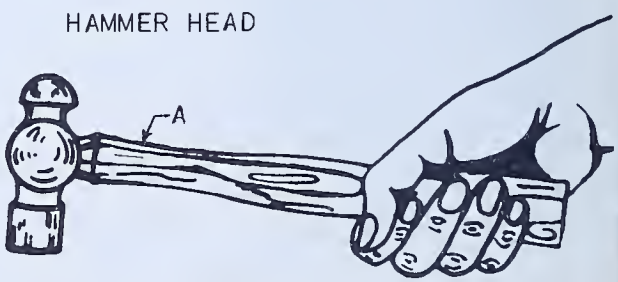


FIG. 57 — *Ball-Peen Hammer*

The handle near the hammer head at point *A*, Fig. 57, is made a little thinner as shown. The narrowing of the handle

makes it springy and eliminates stinging the hand when a blow is struck. Another type of hammer found in the pipe shop is the squarehead hammer.

Things to remember about the use of a hammer include the inspection of the head to see that it is securely fastened to the handle. When the head is loose, drive the wedge farther into the handle. See Fig. 58. If the handle splits, replace it. Strike

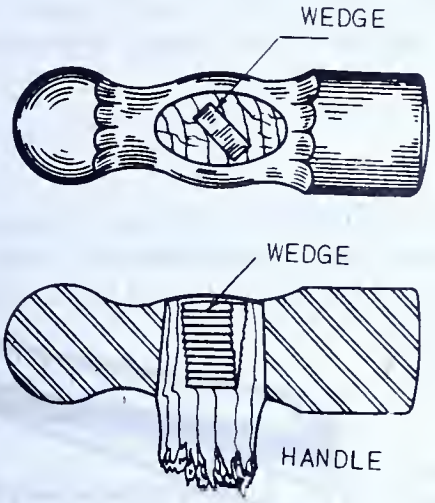


FIG. 58 — *Hammer Head and Wedge*

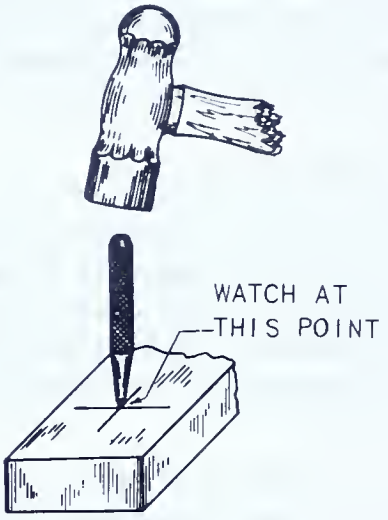


FIG. 59 — *Using a Hammer*

light blows with the hammer at first until assured that the work is starting properly. Watch the point of action while striking with the hammer. Better work will result. See Fig. 59.

CENTER PUNCH

A center punch is used to a considerable extent by the marine pipefitter for laying out holes on the deck for the burner, marking pipe for cutting off and for saddles, lining up flanges for rolling machines, centering for holes to be drilled, etc.

The ordinary center punch (Fig. 60) has a hardened point and a knurled body. The knurled body gives a better gripping surface for the fingers. Center-punch sizes are given by

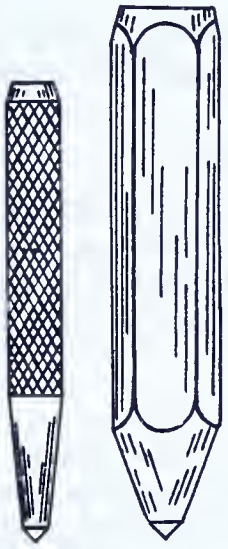


FIG. 60 — *Center Punches*

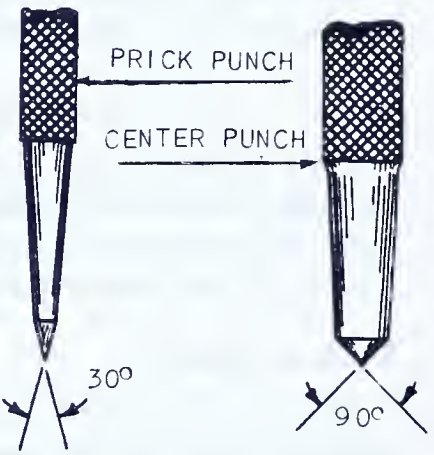


FIG. 61 — *Correct Points for Punches*

letter in tool catalogues. Many fitters, however, dress their own center punches to suit their requirements. The top of the center punch will "mushroom" after continual use. Grind the mushroom off before it spalls and causes injury.

A prick punch is sometimes used by the pipefitter. The point of the prick punch is usually sharpened to an angle of 30 degrees, while the center punch is sharpened to an angle of 90 degrees. See Fig. 61. Do not strike the prick punch with a heavy blow. The prick punch is used for making marks; the center punch is used to make heavier marks for the starting of drills, etc. Inspect the point of the punch before using it to make sure that it is sharp.

Six-Foot Rule

The rule is a constant companion of the marine pipefitter. The most common rule used is six feet long and is a zigzag, or folding, rule. It is divided into twelve six-inch lengths and graduated into one-inch spaces, which are subdivided by intermediate markings of ½ inch, ¼ inch, ⅛ inch, and 1/16 inch graduations. Fig. 62 shows a six-foot folding rule.

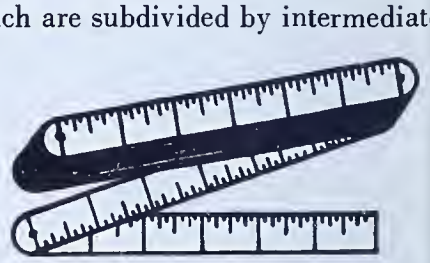


Fig. 62 — *Folding Rule*

It is well to purchase a rule of this type and size because it is a standard for most pipefitters. When the pipefitter purchases a rule, he should remember the following important points: first, that it should be graduated on all edges from one inch down to sixteenths of an inch; and second, that it should have a heavy coat of lacquer to make it more durable. Other features of a good rule are: selected hardwood leaves sealed against moisture, concealed joints having a strike platen on each leaf, and strong spring joints to hold the rule rigid and prevent "jackknifing".

Many rules are made of soft wood, have only an ordinary coat of paint, and become loose in a few days. Badly hinged joints tend to make a rule inaccurate.

Accuracy of the Folding Rule

A folding rule is not so accurate as a steel tape. When the rule becomes worn at the joints, an error of as much as 3/16 of an inch in six feet is possible. It is always better, therefore, to use a steel tape when accurate measurements are to be taken. Six-foot rules are graduated to 1/16 of an inch.

Standard Measure

In order for the layout man to have his work agree with the blueprint, he must follow the sizes given and measure from the center lines or other points exactly as indicated. He must use the same type of measuring tool which was used by the draftsman. It follows, then, that all scales are STANDARD; that is, the length of one inch or one foot on one scale is the same length as one inch or one foot on another scale.

Scale Divisions

When we examine a rule, we find there are many marks, or fine cuts, along its edges. These marks are for the purpose of dividing the length of the scale into many equal parts. No matter how long the scale may be, each inch is found to be exactly the same length. If all the work to be measured were an exact number of whole inches in size, a scale divided into inches would serve the purpose. But this is not so.

Reading Measurements

Measurements are given in feet and inches, or in feet, inches, and parts of an inch. For example: A certain plate is ¾ of an inch thick; 1 foot, 2 inches wide; and 2 feet, 4½ inches in length. Another way of saying the same thing would be: ¾″ x 1′ 2″ x 2′ 4½″. The x used here means "by". For example: 2″ x 4″ is read "two by four inches". Sizes are sometimes given in feet and inches; often they are given in inches or parts of one inch.

Reading Measurements Correctly

A pipefitter must be able to read a rule quickly or he is not a good mechanic. He will lose a lot of time and cause others to lose time unless he can read a rule correctly at the first attempt. To read a rule correctly the mechanic must thoroughly understand its markings.

One-Inch Graduations

On a one-foot scale there are 12 inches; so a one-foot scale has 12 equal spaces, but only 11 marks or dividing lines. The lines mark off the spaces. The spaces are

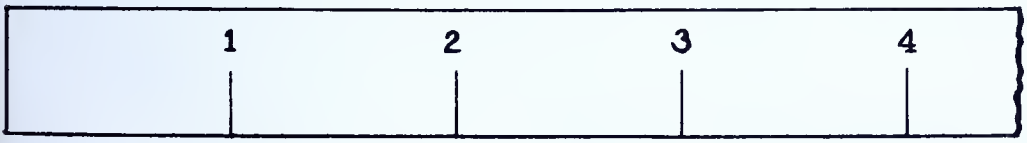


Fig. 63 — *One-Inch Graduations*

called graduations. With the scale indicated in Fig. 63, one can measure as close as one inch.

The markings on the scale show one standard graduation, or division, which in this case is 1 inch. Of course this scale would be all right to measure even inches, but anything less than one inch could not be measured. Marking off each division or graduation into half-inches overcomes this objection. See Fig. 64.

Half-Inch Graduations

Fig. 64 — *Half-Inch Graduations*

Now the markings on the scale show two graduations, or divisions, of the same length in one inch. This scale can be used to measure as close as ½ inch. But the work has to be measured much closer than ½ inch; therefore the graduations or divisions must be made still finer.

Quarter-Inch Graduations

The markings on the scale (Fig. 65) show four graduations, or divisions, of the same length in one inch. This scale could be used to measure as close as ¼ inch.

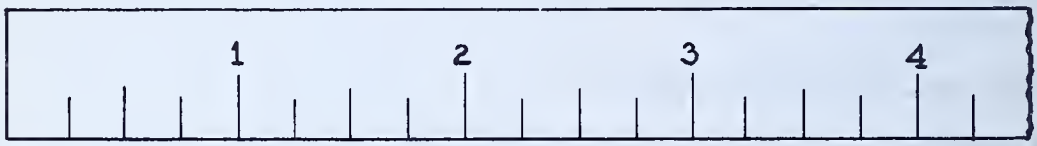


Fig. 65 — *Quarter-Inch Graduations*

Eighth-Inch Graduations

The markings on the scale (Fig. 66) show eight graduations, or divisions, of the same length in one inch. This scale could be used to measure as close as ⅛ inch.

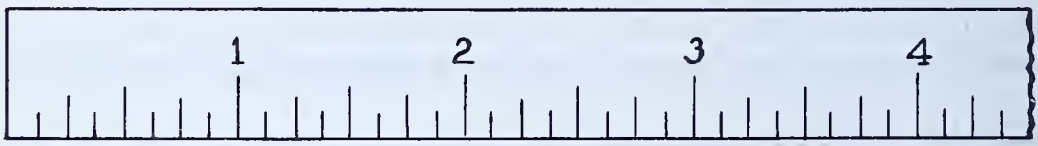


Fig. 66 — *Eighth-Inch Graduations*

Sixteenth-Inch Graduations

The markings on the scale shown in Fig. 67 indicate sixteen graduations, or divisions, of the same length in one inch. This scale can be used to measure as close as 1/16 inch.

This is as close a reading as is found on a 6′ rule.

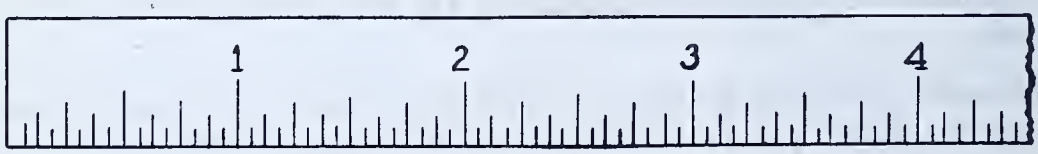


Fig. 67 — *Sixteenth-Inch Graduations*

6″ Steel Scale

The 6″ scale is a handy pocket tool that may be carried at all times while on the job. It is a useful scale to use for measuring in close quarters. A good steel scale will outlive its owner if it is treated properly. The numbers and dividing lines on the scale are stamped into the steel and will not wear off. Usually the four edges of the rule have different graduations. One side is graduated in 8ths and 16ths while the other side is graduated in 32nds and 64ths.

Square

A square is a steel right angle, with which the pipefitter can measure, check edges or surfaces for evenness, test flanges for squareness, and check drills and taps for perpendicular bore. Squares vary in size from three to eighteen inches or more. In the pipe shop, a square is usually made from sheet stock and is used for testing purposes and for the same uses as a straightedge. See Fig. 68. If there is any doubt about the accuracy of a square, refer to Appendix VIII, Applied Arithmetic, for an easy method of testing.

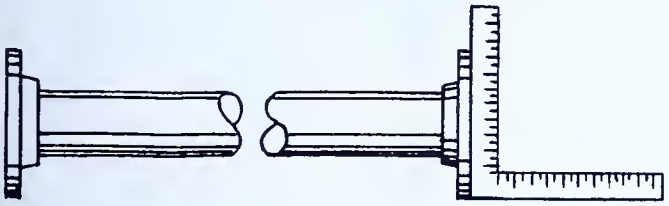


Fig. 68 — *Testing a Flange with a Square*

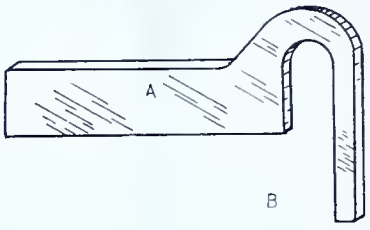


Fig. 69 — *A Flange Square*

Another type of square found in some pipe shops is the flange square. The flange square is usually made in the shop from ⅜″ plate and may be found in many shapes and sizes, but all serve the same purpose. Figure 69 shows one type of flange square. Part *A* is placed on the pipe, and part *B* fits over the end of the pipe on the surface of the flange. In this manner it may be determined whether or not the flange is square with the pipe.

Easy-Out (Extractor)

An easy-out is a tool used to remove a broken stud or bolt from a hole. It is also used to remove broken nipples from threaded fittings and flanges. Stud threads and bolt threads often rust in the hole and break under the strain of trying to turn them out. There are a number of special tools available for this purpose. They are called removing tools. A knowledge of the use of a re-

Fig. 70 — *Extractors (Easy-Outs)*

moving tool (easy-out) will greatly aid the pipefitter in doing a job in the quickest way and without damage to other parts. Fig. 70 shows two types of stud and bolt extractors.

Trammels

Trammels are used in place of dividers where the radius is too long. See Fig. 71. There are several styles and sizes of trammels. This variety makes it possible to

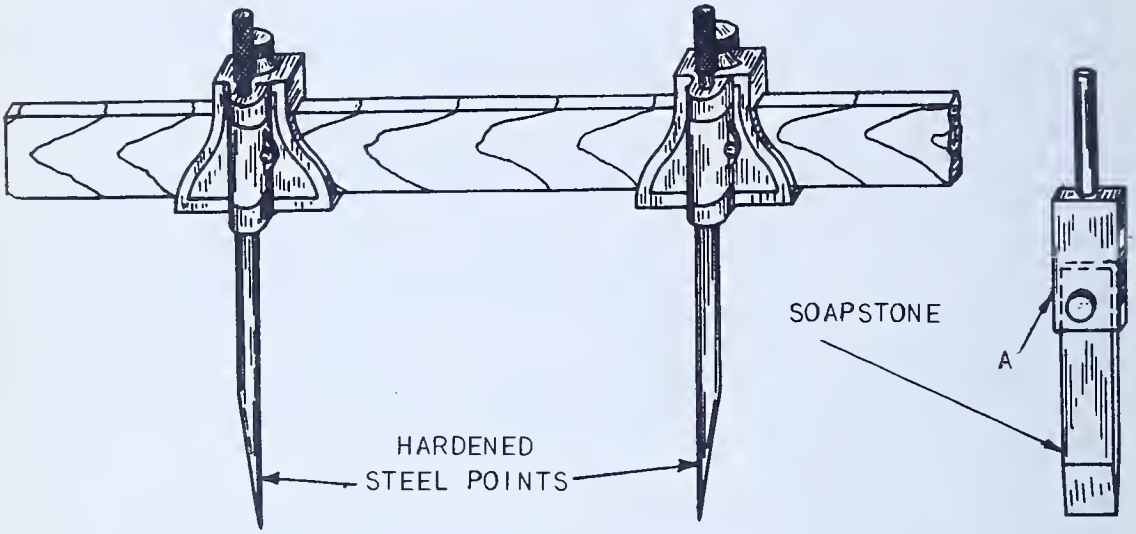


Fig. 71 — *Trammels*

get into many different places that would ordinarily be hard to reach. In marine pipefitting the trammels are used to scribe curved lines so that the pipefitter can make his templates to suit various radii, arcs, and circles.

A special trammel leg *A*, Fig. 71, may be used to scribe arcs and circles. It substitutes a piece of soapstone for the usual, inserted hardened point.

Chalk Line

A chalk line is a heavy, woven cotton cord and is used to make long, straight lines between two points too far apart to allow for the use of a square or a straightedge. After chalk has been applied (Fig. 72), the line is stretched taut between the two points. About halfway between the two points the line is pulled up and then released quickly. The line will snap to its original position and leave a chalked line on the surface of the work. Do not pull the line off to either side, but at right angles to the surface of the work.

Chalk should be rubbed on the line without wearing a groove in the chalk. Grooves in the chalk will eventually break it and make it useless for chalking a line.

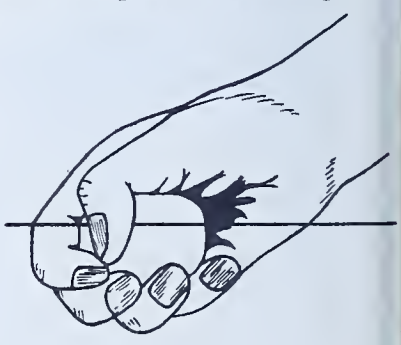


Fig. 72 — *Chalk Line*

FIG. 73 — *Drift*

DRIFTS

Drifts, or drift pins, as they are often called, are long, cone-shaped pieces of steel used to line up holes in flanges and steel plates. See Fig. 73. The size of the pin depends on the size of the holes the drift must fit. The drift is used primarily to move bolt holes into line so that the bolts can be installed. When two over lapping plates have holes in their edges for rivets or bolts, the holes are lined up by inserting a drift through two of them and working the drift sidewise until the holes are drawn into line so that a rivet or bolt can be pushed through properly matched adjoining holes. Extreme caution must be exercised in using a drift on cast-iron flanges and fittings as they are easily broken.

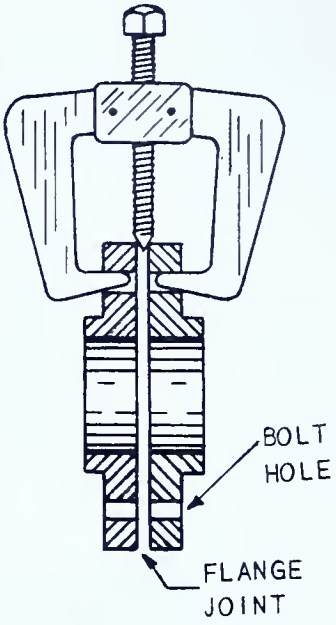


FIG. 74 — *Flange Spreader*

FLANGE SPREADER

The flange spreader is a tool used by pipefitters to force flanges apart so that a gasket may be inserted. This tool is used chiefly on repair work where removing a fitting or a section of pipe is impractical and expensive. See Fig. 74.

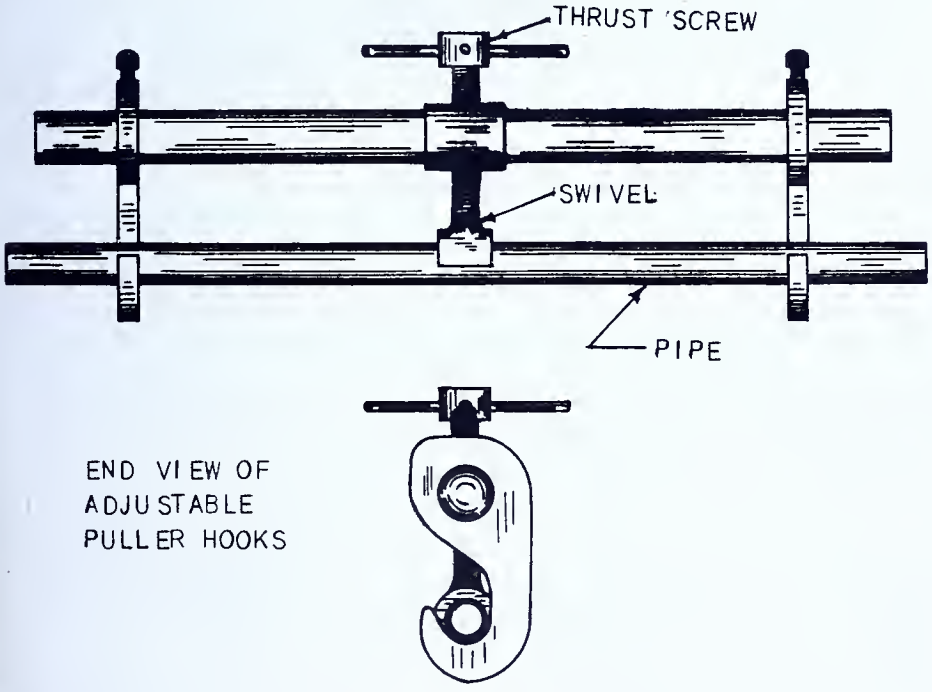


FIG. 75 — *Rail Straightener*

Rail Straightener

The rail straightener is a tool that is used to straighten pieces of bent handrail as shown in Fig. 75. The rail to be straightened is placed on the puller hooks. The handle on the thrust screw is turned; this forces the bent section of pipe into a straight line.

Nipple Chuck

A nipple chuck (Fig. 76) is a tool that is used to make nipples that are too short to be held in a vise or pipe machine. There are a number of ways of making a chuck, the most common of which requires only a piece of cold-rolled steel and a pipe coupling or socket. By cutting a deep thread on the piece of cold-rolled steel approximately three-fourths of the length of the socket, the socket when screwed on the steel

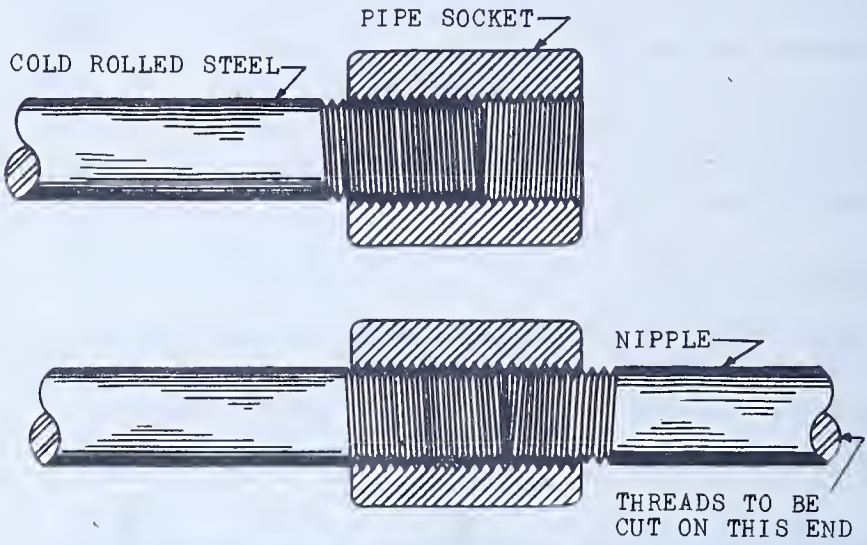


Fig. 76 — *Nipple Chuck*

rod will run on very easily and leave enough threads into which a nipple may be screwed. One end of the nipple is screwed into the socket until it touches the steel bar which stops it from turning while a thread is cut on the other end of the nipple. To remove the nipple from the chuck, loosen the socket with a pipe wrench and remove the nipple by hand. If the socket has a tendency to screw off with the nipple, tap it lightly several times with the handle of a wrench.

Steel Tape

The marine pipefitter will find it much to his advantage to have in his possession a fifty-foot steel tape instead of a twenty-five foot or a six-foot tape.

Very long measurements can be made with a fifty-foot tape, but it must be used correctly or faulty measurements will result.

On the end of the tape there is a stiff wire loop. See Fig. 77. Caution must be taken in measuring from the end of the loop as it is one inch from the outside end of the loop to the figure 1 on the tape. This loop keeps the tape from being lost in the casing when the pipefitter winds up the line at the conclusion of his measurement. Always measure from the outside end of the loop. Do not allow the loop to become folded over or under.

All steel tapes used where accuracy is required should be checked frequently with the tape belonging to an official of the company and kept by him for this purpose. Some mechanics check their tapes twice a week on regular days, Monday and Thursday, before starting work on those days. To make the check, reel out the official's tape far enough to check the total footage marked on the tape to be used on a specific job. Run out the tape to be checked, place the zeros of the two tapes even, and check the indicated foot mark on the tape with that foot mark on the official's tape. If they correspond exactly, the tape checked may be put into use. If there is any discrepancy at the indicated foot mark, do not use this tape for accurate work.

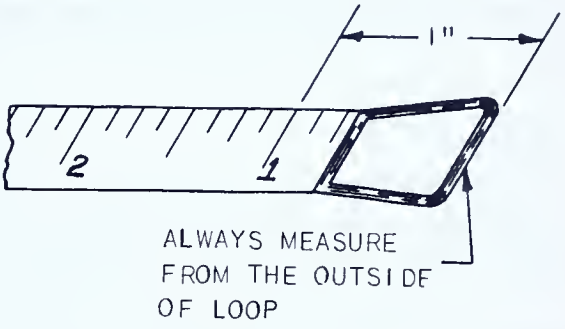


FIG. 77 — *Loop on Steel Tape*

In using a steel tape always keep it straight. Never hold it or lay it down in such a way that it will kink. A kinked tape is inaccurate and will soon break.

In placing the one-foot mark on a point, the *center* of the scale mark must be put exactly on the point.

Never walk on a tape or drop anything on it, because it is a fragile, sensitive tool.

When measurements are to be taken that will necessitate unreeling the full length of the tape, unreel the full length and lay the tape carefully alongside the line on the floor where measurements are to be made. Stand the reel or case up on the floor to keep all of the tape perfectly flat right up to the case.

If a tape is to be left any length of time stretched out on the floor, lay template boards

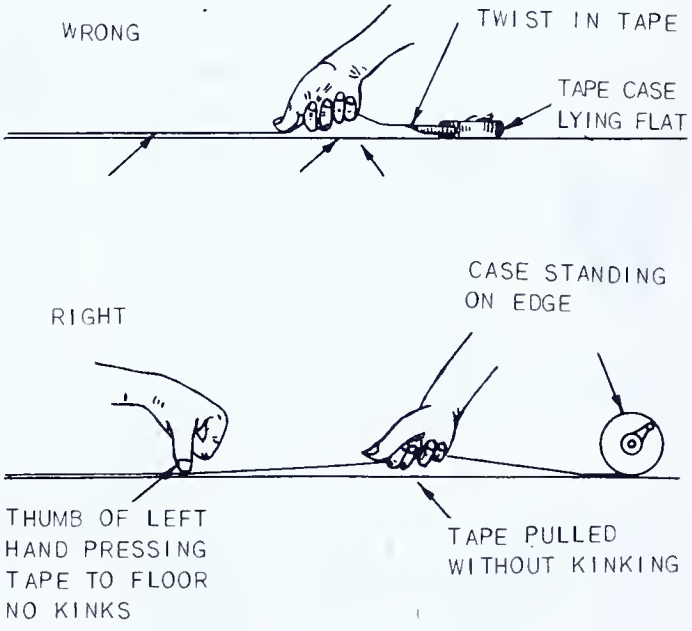


FIG. 78 — *Measuring with Steel Tape*

close up to the tape or the full length of the stretched-out portion. The edge of the template board will keep anyone from actually stepping on the tape. A shoe will clear the tape because the thickness of the template board will force the shoe to "bridge" over the tape lying alongside.

To pull a steel tape to get slack out of it, place the thumb on top of it and the fingers of the same hand under the tape and pull. *Do Not Press the Thumb to the Floor.* To do so will make a sharp bend in the tape back of the thumb and may permanently damage the tape by kinking it. Pull the tape at a point 12 inches beyond a mark, press the tape to the floor at the mark (which will be 12 inches from the thumb and fingers pulling the tape, and no possible kink may result. See Fig. 78.

Gasket Punch

A gasket punch (shown in Fig. 79) is often used to cut bolt holes in gaskets. Gasket punches are made in many different sizes and are used in the same manner as a center punch; that is, the punch is placed on the material with the sharpened edges of the punch on the bolt-hole location and then it is struck with a hammer. This procedure produces a clean-cut bolt hole in the gasket. Care must be exercised to see that the gasket is not placed on metal, for metal will dull the edges of the punch. The end grain of a block of wood should be used for backing.

Fig. 79 — *Gasket Punch*

Dividers

Dividers most commonly used in the shop are the Yankee-pattern spring dividers. The two legs are held apart by a stiff clip spring located in the top. The opening between the legs is adjusted by turning the knurled knob on the adjusting screw. The two pointed ends are hardened and then whetted to sharp points.

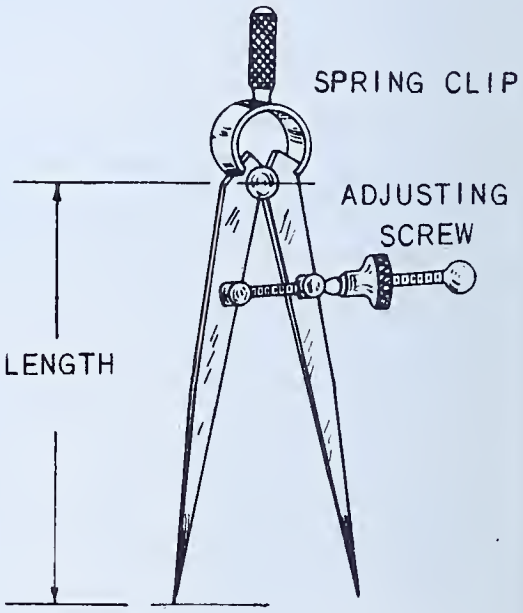


Fig. 80 — *Spring Dividers*

Distances may be measured with the dividers and then transferred to the work; they may be set on one piece of work and then be used to transfer measurements to a similar piece of work being constructed. Since the points are hardened they may be used to describe circles on metal plate.

Dividers are extremely valuable for all kinds of layout work. In the making of

template layouts they are an absolute necessity. They take the place of the compass and the scriber in making circles and arcs on template paper.

Fox Wedges

These wedges appear in many types of work in the shipyard. They are made of tool steel and should be handled accordingly. The wedges are about 3½" long, 1" wide, and ⅜" thick at the butt end. The thin end is dressed to a sharp edge and should be kept that way.

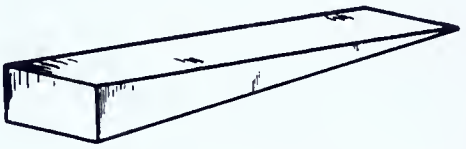


FIG. 81 — *Fox Wedge*

Such jobs as prying apart flanges for inspection, raising a heavy section to align bolt holes, etc., are frequently encountered by the marine pipefitter. Fox wedges provide an easy means of accomplishing these small jobs.

Plumb Bob and Line

In some instances it will be necessary to align certain pipes vertically, i.e. straight up and down. For this work the plumb bob proves indispensable. In marine work, because of the fact that the ship is inclined on the ways, everything is usually on a slant and the use of the plumb bob must be confined to checking by sight.

FIG. 82 — *Plumb Bob*

An occasion might arise where flanged pipes would have to be closely matched because of the bolt holes in the flanges. When large bent pieces are being installed, alignment must be taken into consideration. A plumb bob may be used to align or check the position of the bolt holes in the installed flange; then the proper location of the flange can be found in the shop. This is especially important where welded flanges are used.

If a regular plumb (as shown in the illustration) is not available, an excellent substitute can be made with a heavy nut or bolt and a piece of string.

Soapstone

This gray mineral received its name from the soapy feeling experienced when it is rubbed between the fingers. It is used wherever temporary markings have to be made. It is sturdier than chalk, and the marks made with it are not rubbed off quite so easily as are chalk lines. Because of its flat shape it can be used to good advantage with a straightedge. In work where trammels have to be used, special holders for soapstone make it possible to scribe large circles or arcs.

FIG. 83 — *Soapstone*

Screwdriver

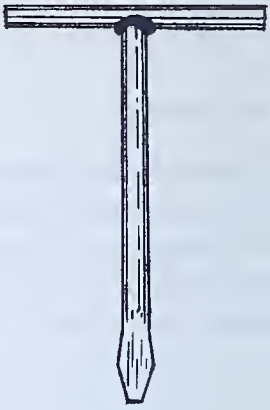


Fig. 84 — *Screwdriver*

Certain valves, faucets, and similar fittings have to be disassembled or repaired with a screwdriver. A type preferred by pipefitters is one made in the shop (See Fig. 84). It is made of two pieces of drill rod or steel bar welded together in the form of a tee. The end may be flattened out before it is ground to shape or it may be tapered down from the round stock. This type is preferred because the bar handle provides more leverage.

Architects Two-Foot Folding Rule

This rule (Fig. 85) is graduated to 8ths, 10ths, 12ths, and 16ths of an inch. In addition to these regular scales there are drafting scales along the inside beveled edges for scaling blueprints. For information concerning the use of drafting scales, see Part V, Pipefitting Practice.

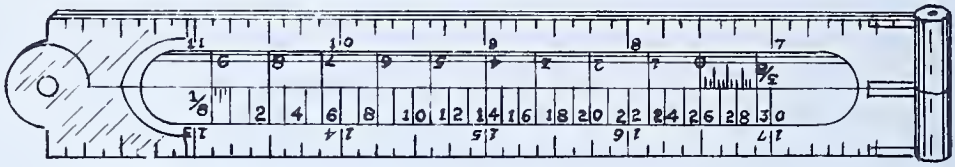


Fig. 85 — *Architects Folding Rule*

Chain Jacks

Frequently on board ship large pipes have to be lifted or lowered into places where regular hoists or cranes cannot be used. The larger pipes cannot possibly be held in position by the pipefitter. A chain jack is used in such cases. Two sizes are available. The smaller jack will lift weights from ¾ ton (with the single chain) to 1½ tons (with the double chain). The larger jack will lift 1½ tons with the single chain and 3 tons with the double chain. The illustration shows the chain used double. In this case the chain is run through a sprocket wheel, to which the hook is fastened. When used singly, the chain does not go

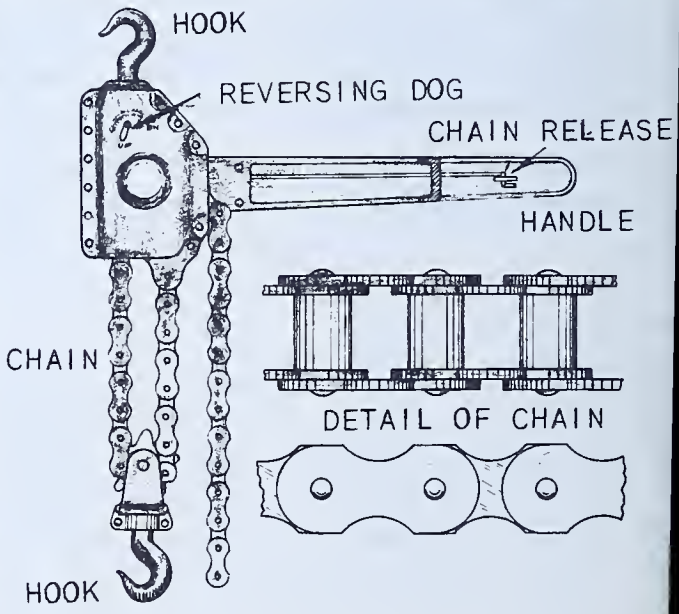


Fig. 86 — *Chain Jack*

through the sprocket and then fasten to the jack, but it is fastened directly to the hook. A small lever located on the opposite side of the handle releases the ratchet inside the head of the jack and makes it possible to pull the chain through the jack by hand. This feature greatly speeds up the taking in of slack chain. A lever located on the side of the jack body makes it possible to lift or lower a weight depending upon the direction in which the lever is pointed. See Fig. 86.

QUESTIONS

1. **Explain why there is a right and a wrong way to pull on an adjustable wrench.**
2. **What type of wrench is used on polished or nickled pipe?**
3. **Explain the advantage of a 12-point box wrench.**
4. **The number of teeth per inch on a hacksaw blade is an important factor to be considered. Explain why.**
5. **Why should cutting wheels on pipe cutters be kept sharp?**
6. **What results when dies having dull or chipped teeth are used to cut threads?**
7. **The heads of chisels are not tempered. What danger arises when a chisel has been frequently used?**
8. **Why should good handles always be placed on files?**
9. **Name the three kinds of taps and give their uses.**
10. **What safety precautions are to be observed with regard to the use of the hammer?**
11. **List the features of a good folding rule.**
12. **What advantages have trammels over dividers?**
13. **Of what use is the chalk line?**
14. **Why should the pipefitter have in his possession a long steel tape rather than a short one?**
15. **Give several uses of fox wedges.**
16. **For what is an architects scale used?**
17. **What means are used to hold heavy pipes in close quarters?**

PART IV

CLASSIFICATION, IDENTIFICATION, AND REPRESENTATION OF MATERIALS

INFORMATION SHEET NO. 1
PIPE SPECIFICATIONS

Classification of Pipe Material

The modern marine pipefitter comes in contact with many types of fittings, valves, joints, etc., made from several different kinds of metal. Iron, steel, brass, copper, and lead are the most common metals used in pipefitting. The pipefitter must be acquainted with the general properties of these different materials. He must know their strengths and must know the peculiarities of each of them in order to perform his job efficiently as a pipefitter.

Wrought-Iron Pipe

Wrought-iron pipe differs from other types of pipe in that it is composed of highly refined iron and a small portion of silicate. The iron silicate, or slag, is distributed through the iron base metal in fibrous threads which extend in the direction of the rolling. There may be as many as 250,000 of these glasslike threads to each cross-sectional square inch. The presence of these fibers gives wrought iron pipe a tough, fibrous structure. Wrought iron pipe may be recognized by checking the waste material cut from the pipe thread. This material will break up in a fashion similar to that of cast iron.

Formerly, wrought iron was the preferred metal for the best class of work, but records of installations and tests have demonstrated that steel pipe is equal to wrought-iron pipe for general work and that it resists corrosion in the average case as well as wrought iron. Then, too, steel pipe is stronger and cheaper.

The Manufacture of Steel Pipe

Butt Welding — Small pipes for ordinary uses, such as for low-pressure steam, liquid, or gas lines may be made by the butt-welding process from Bessemer steel. This type of steel is used mainly because of its low cost and its superior furnace welding characteristics which are due to the high phosphorous content.

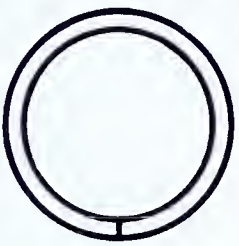


Fig. 87 — *Butt-Welded Pipe*

In the butt-welding process, a strip, or plate termed "skelp", is pulled at welding heat through a ring die, or bell. The tube is

formed and welded together in a single operation. Butt welding may be recognized by a single seam on the outside. See Fig. 87. The inside should be smooth. If it is difficult to identify, cut the pipe. Cutting will bare the seam for identification. Generally, pipe ⅛ inch to 3 inches in diameter is butt welded unless otherwise specified.

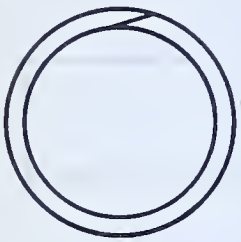


FIG. 88 — *Lap-Welded Pipe*

Lap Welding — For ordinary purposes pipe two inches or more in diameter is usually made by the lap-welding process.

Open-hearth steel is ordinarily used for lap welding, but some Bessemer steel is also used, particularly for smaller sizes of the lap-welded pipe; rimming steel is most commonly used, but where service conditions require a better grade, "killed" steel is selected.

Lap-welded pipe is made from flat plate, or skelp, with scarfed edges. This material is drawn hot through a bell that forms the skelp into pipe with the edges overlapped. The rolled-up plate is maintained at welding heat while being welded together between a "ball" inside the pipe and the welding rolls. Rolling operations are then used to straighten and finish the pipe.

Lap welding may be recognized by a seam and a light line along the side. See Fig. 88. If identification is difficult, the pipe may be cut for a cross-sectional view which will show the lap joint. Pipe 2 inches to 6 inches in diameter is lap welded.

Seamless Pipe — Of the three processes used in the manufacture of seamless pipe, namely, the Pilger, Cupping, and Mannesman plug-mill process, the last is used almost exclusively in this country as well as abroad. This process produces high-quality seamless pipe for power plant purposes.

Hot Drawn Tubing — The Mannesman plug-mill process is one in which a round

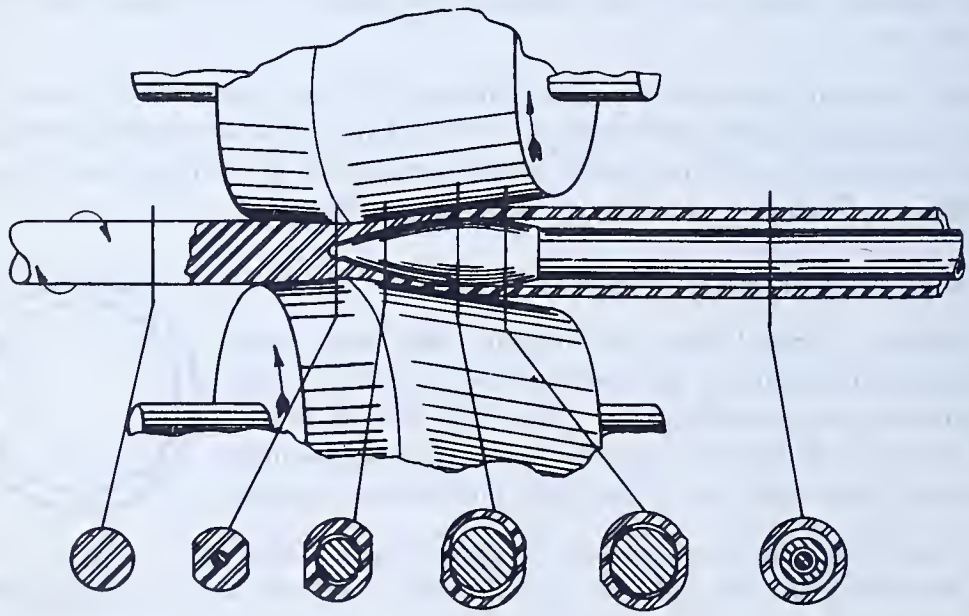


FIG. 89 — *Mannesman Plug-Mill Process*

billet of high-quality chilled steel is heated to a high temperature and then forced over the rounded nose of a piercing mandrel by revolving rolls. This procedure produces a seamless tube of rather thick walls. See Fig. 89.

When it is necessary to expand the tube to a greater diameter, a second mandrel is used. A plug or ball is inserted in the tube, and the latter is passed through rolls that simultaneously thin its walls and lengthen it. The tube is then trued and straightened by passing it through a series of cross rolls; then it is heated again and run through sizing rolls.

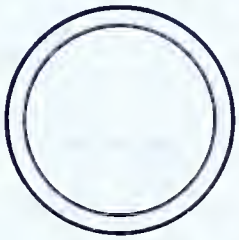


FIG. 90 — *Seamless Pipe*

To produce thin-walled pipe that is larger than 16 inches in diameter, a special rotary expander must be used after the first rolling process. See Fig. 90.

Cold Drawn Tubing — Cold drawn tubing is given the same treatment (piercing, rolling, and sizing, or reducing) as tubes that are to be hot finished. However, cold drawing is pulling the tube through a die with a hole that is smaller than the tube. A plug or mandrel located on the inside of the tube within the die, controls the inside diameter of the pipe. It is necessary to heat the steel tubing after each trip through the die, as cold drawing will make the metal hard.

Cold drawing is done mainly to allow for finer dimensions, production of pipe with smaller diameters, and thinner wall thickness of tubes having great length.

STANDARD WEIGHTS AND DIMENSIONS

Table No. 1 is for standard weights and dimensions of welded and seamless steel pipe. These specifications cover black and hot-dipped galvanized "standard weight", "extra strong", and "double extra strong", welded, and seamless steel pipe. Pipe ordered under these spcifications is intended for all ordinary uses. The steel for welded pipe shall be of a quality made by the open hearth, electric furnace, or Bessemer process. The steel for a seamless pipe shall be made either by the open hearth method or by the electric furnace.

Welded pipe 3 inches in diameter or under will be butt welded, unless otherwise specified. Welded pipe of 3 inches in diameter or over shall be lap welded or electric welded.

Galvanized pipe shall be coated with zinc inside and outside by hot-dip process.

The weight of the zinc coating shall not be less than 2.0 ounces (weight of coating expressed in ounces per square foot) and shall be calculated by dividing the total weight of the zinc (inside plus outside) by the total area (inside plus outside) of the surface coated.

Table No. 1

			"STANDARD WEIGHT" PIPE		"DOUBLE EXTRA - STRONG" PIPE		"EXTRA - STRONG" PIPE	
Nominal Diameter in Inches	Outside Diameter in Inches	Threads Per Inch	Thickness in Inches	Weight Per Foot With Couplings in Pounds	Thickness in Inches	Weight Per Foot, Plain Ends in Pounds	Thickness in Inches	Weight Per Foot, Plain Ends in Pounds
⅛	0.405	27	0.068	0.25	0.095	0.31	.....	.....
¼	0.540	18	0.088	0.43	0.119	0.54	.....	.....
⅜	0.675	18	0.091	0.57	0.126	0.74	.....	.....
½	0.840	14	0.109	0.85	0.147	1.09	0.294	1.71
¾	1.050	14	0.113	1.13	0.154	1.47	0.308	2.44
1	1.315	11½	0.133	1.68	0.179	2.17	0.358	3.66
1¼	1.660	11½	0.140	2.28	0.191	3.00	0.382	5.21
1½	1.900	11½	0.145	2.73	0.200	3.63	0.400	6.41
2	2.375	11½	0.154	3.68	0.218	5.02	0.436	9.03
2½	2.875	8	0.203	5.82	0.276	7.66	0.552	13.70
3	3.500	8	0.216	7.62	0.300	10.25	0.600	18.58
3½	4.000	8	0.226	9.20	0.318	12.51	0.636	22.85
4	4.500	8	0.237	10.89	0.337	14.98	0.674	27.54
5	5.563	8	0.258	14.81	0.375	20.78	0.750	38.55
6	6.625	8	0.280	19.19	0.432	28.57	0.864	53.16
8	8.625	8	0.277	25.00	.....	.....	0.875	72.42
8	8.625	8	0.322	28.81	0.500	43.39	.....	.....
10	10.750	8	0.279	32.00	.....	.....	.....	.....
10	10.750	8	0.307	35.00	.....	.....	.....	.....
10	10.750	8	0.365	41.13	0.500	54.74	.....	.....
12	12.750	8	0.330	45.00	.....	.....	.....	.....
12	12.750	8	0.275	50.71	0.500	65.42	.....	.....

Standard Weights and Dimensions of Welded and Seamless Steel Pipe

Relative Strengths of Pipe

If it is assumed that seamless steel pipe has a strength of 100 per cent, butt-welded steel pipe will have a comparative strength of 73 per cent, and lap-welded steel pipe a comparative strength of 92 per cent. The relative strengths of wrought-iron pipe and steel pipe are as follows: Butt-welded wrought-iron pipe has 70 per cent of the strength of butt-welded steel pipe, and lap-welded wrought-iron pipe has 57 per cent of the strength of similar lap-welded steel pipe.

Classification of Different Types of Steel Pipe

STEEL PIPE	BUTT-WELD PIPE	STD. PIPE	GALVANIZED
			BLACK
		XH PIPE	GALVANIZED
			BLACK
		XXH PIPE	BLACK
	LAP-WELD PIPE	STD. PIPE	GALVANIZED
			BLACK
		XH PIPE	GALVANIZED
			BLACK
		XXH PIPE	BLACK
	SEAMLESS PIPE	STD. PIPE	GALVANIZED
			BLACK
		XH PIPE	GALVANIZED
			BLACK
		XXH PIPE	BLACK

STD. = STANDARD PIPE

X-H = EXTRA-HEAVY PIPE

XX-H = DOUBLE EXTRA-HEAVY PIPE

Types of Pipe Used for Specific Purposes

Standard, galvanized-steel pipe is used for water. Corrosion is very much reduced by the zinc covering on the pipe.

Black pipe is used for steam radiation, steam-heating systems, air lines, and oil lines, unless otherwise specified.

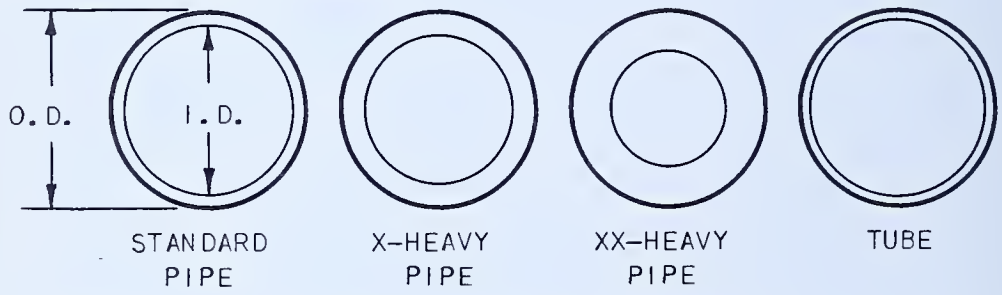
Brass pipe and copper pipe may be used for salt water, steam, and drain lines as specified.

Lead pipe is frequently used in waste systems.

For pressure under 150 pounds, standard, seamless, galvanized steel pipe or black steel pipe may be used. For pressure above 150 pounds, extra-heavy, seamless pipe must be used.

Comparison of Wall Thicknesses

Figure 91 gives a comparison of the wall thicknesses of the three grades of pipe and of tubing. The outside diameter is used to measure pipe over 14 inches. On pipe 12″ and under the inside diameter is used for measuring. The inside diameter also varies according to weight.



NOTE: THE OUTSIDE DIAMETER NEVER CHANGES — THE INSIDE DIAMETER VARIES ACCORDING TO WEIGHT.

Fig. 91 — *A Comparison of Wall Thickness*

QUESTIONS

1. Explain why steel pipe is replacing wrought-iron pipe.
2. If seamless pipe is stronger than lap-welded or butt-welded pipe, why are not all pipes made seamless?
3. Explain the difference between cold-drawn and hot-drawn tubing.
4. Why is pipe sometimes galvanized?
5. Is double extra-heavy pipe ever galvanized?
6. What two weights of seamless pipe are sometimes galvanized?
7. What is the major difference between tubing and pipe?

INFORMATION SHEET NO. 2
FITTINGS: TYPES AND USES

Flanged Fittings

In marine pipefitting it is essential for one to be able to recognize all types of fittings and to know the purposes for which they are made.

The following figures are a number of flanged fittings commonly used in marine piptfittings:

90° Elbow — (Ell) Fig. 92 — A fitting that makes an angle between two adjacent pipes. The angle is always 90° unless another angle is stated.

45° Elbow — Fig. 93 — A fitting that makes an angle between two adjacent pipes. Elbows other than 90° are specified as such. A 45° elbow will form an angle of 45° with both the horizontal line and the axis of the pipe. Other common angles are 22½° and 60°.

Side Outlet Elbow — Fig. 94 — A fitting that makes a three-way pipe connection at right angles to each other.

Tee — Fig. 95 — A fitting, either cast or forged, that has one side outlet at right angles to the run. A single-outlet branch pipe is shown.

Cross — Fig. 96 — A pipe fitting with four branches arranged in pairs, each pair on one axis, and the axes at right angles. When the outlets are arranged in a different manner, the fittings are branch pipes or specials.

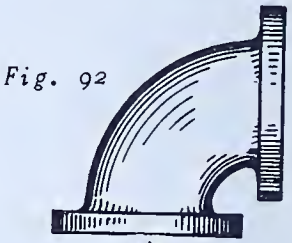


Fig. 92

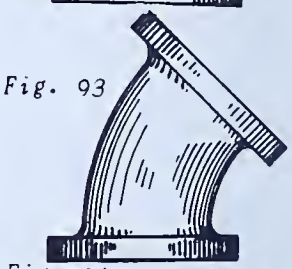


Fig. 93

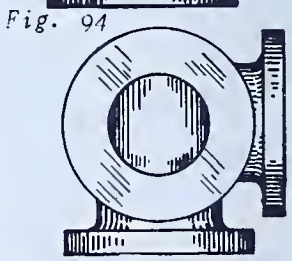


Fig. 94

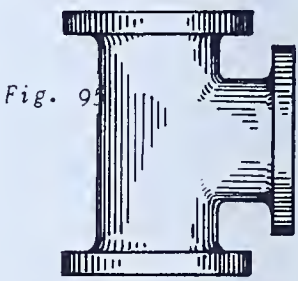


Fig. 95

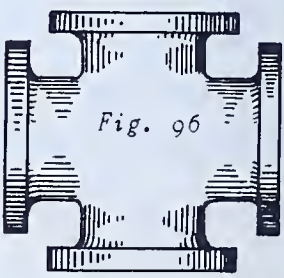


Fig. 96

45° Lateral, (sometimes called a *Y*) Fig. 97 — A pipe fitting that may be either cast or forged, and that has one side outlet at an angle other than 90°, usually 45°.

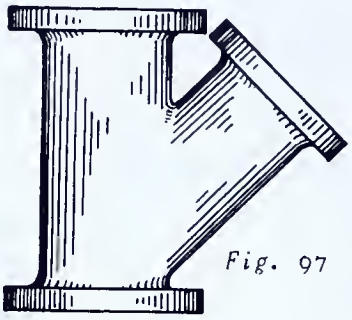


Fig. 97

Taper Reducer, Fig. 98 — A fitting that has a larger size of opening at one end than at the other. Both openings are on the same center line (concentric).

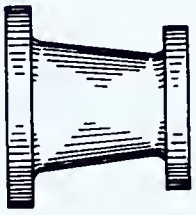


Fig. 98

Eccentric Reducer, Fig. 99 — A fitting with a taper body, having openings on center lines that are not concentric.

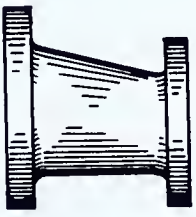


Fig. 99

Y Branch (A Wye) Fig. 100 — A fitting the shape of which is nearly like that of the letter Y.

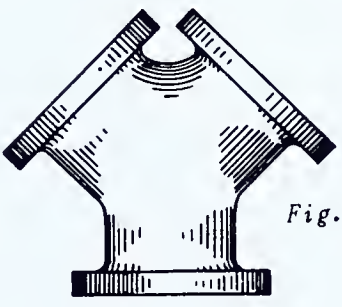


Fig. 100

125 Pounds Pressure — Flanged Fittings

Flanged fittings for 125 pounds pressure are usually made of cast iron. The flanges are plain-faced with a smooth finish. The dimensions of the flanges and the number and diameter of their corresponding bolts are listed in Table No. 2. Refer to Fig. 101 for dimensions.

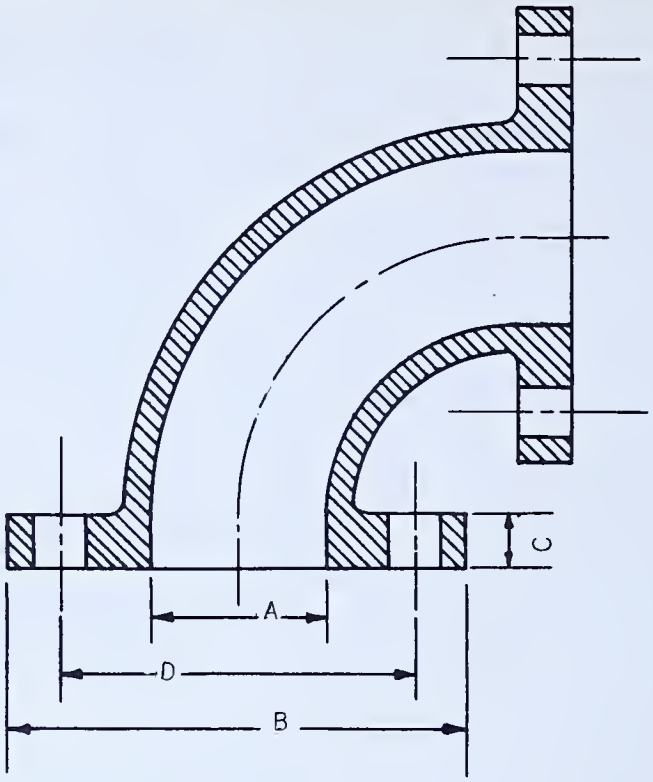


FIG. 101

Table No. 2

AMERICAN STANDARD CLASS 125 CAST-IRON PIPE FLANGES

NOMINAL PIPE SIZE	DIAM. OF FLANGE	THICK-NESS OF FLANGE (MIN.)	DIAM. OF BOLT CIRCLE	NUMBER OF BOLTS	DIAM. OF BOLTS	DIAM. OF DRILLED BOLT HOLES	LENGTH OF BOLTS	SIZE OF RING GASKET
1	4-1/4	7/16	3-1/8	4	1/2	5/8	1-3/4	1 X 2-5/8
1-1/4	4-5/8	1/2	3-1/2	4	1/2	5/8	2	1¼ X 3
1-1/2	5	9/16	3-7/8	4	1/2	5/8	2	1½ X 3-3/8
2	6	5/8	4-3/4	4	5/8	3/4	2-1/4	2 X 4-1/8
2-1/2	7	11/16	5-1/2	4	5/8	3/4	2-1/2	2½ X 4-7/8
3	7-1/2	3/4	6	4	5/8	3/4	2-1/2	3 X 5-3/8
3-1/2	8-1/2	13/16	7	8	5/8	3/4	2-3/4	3½ X 6-3/8
4	9	15/16	7-1/2	8	5/8	3/4	3	4 X 6-7/8
5	10	15/16	8-1/2	8	3/4	7/8	3	5 X 7-3/4
6	11	1	9-1/2	8	3/4	7/8	3-1/4	6 X 8-3/4
8	13-1/2	1- 1/8	11-3/4	8	3/4	7/8	3-1/2	8 X 11
10	16	1- 3/16	14-1/4	12	7/8	1	3-3/4	10 X 13-3/8
12	19	1- 1/4	17	12	7/8	1	3-3/4	12 X 16-1/8

NOTE: All bolt holes are drilled at least 1/16 inch larger than the diameter of the bolt.

150, 300, and 600 Pounds Pressure — Flanged Fittings

Flanged fittings for these pressures are usually made of cast steel. The flanges have a raised face as shown in Fig. 102. The dimensions of the flanges and their bolts are listed in Tables Nos. 3, 4 and 5.

The Standard Height of the Raised Face (Dim. *X*) for 150-Pound Flanges is 1/16″

The Standard Height of the Raised Face (Dim. X) for 300-Pound Flanges is 1/16″

The Standard Height of the Raised Face (Dim. X) for 600-Pound Flanges is ¼″

Note: All bolt holes are drilled at least 1/16 inch larger than the diameter of the bolt.

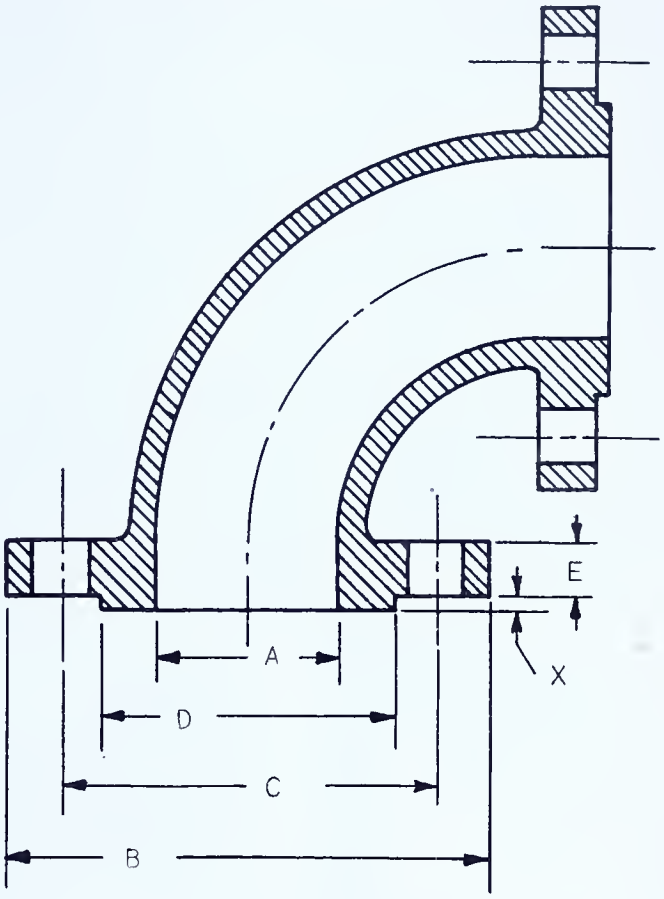


Fig. 102

Table No. 3

150-POUND CAST-STEEL VALVES AND FITTINGS
DIMENSIONS OF AMERICAN STANDARD STEEL-FLANGE FACINGS

NOMINAL PIPE SIZE	DIAMETER FLANGE	DIAMETER BOLT CIRCLE	DIA. RAISED FACE	FLANGE THICKNESS	NO. OF BOLTS	SIZE OF BOLTS DIAMETER
DIM. A	DIM. B	DIM. C	DIM. D	DIM. E		
1	4-1/4	3-1/8	2	7/16	4	1/2
1-1/4	4-5/8	3-1/2	2-1/2	1/2	4	1/2
1-1/2	5	3-7/8	2-7/8	9/16	4	1/2
2	6	4-3/4	3-5/8	5/8	4	5/8
2-1/2	7	5-1/2	4-1/8	11/16	4	5/8
3	7-1/2	6	5	3/4	4	5/8
3-1/2	8-1/2	7	5-1/2	13/16	8	5/8
4	9	7-1/2	6-3/16	15/16	8	5/8
5	10	8-1/2	7-5/16	15/16	8	3/4
6	11	9-1/2	8-1/2	1	8	3/4
8	13-1/2	11-3/4	10-5/8	1- 1/8	8	3/4
10	16	14-1/4	12-3/4	1- 3/16	12	7/8
12	19	17	15	1- 1/4	12	7/8

Table No. 4

300-POUND CAST-STEEL VALVES AND FITTINGS
DIMENSIONS OF AMERICAN STANDARD STEEL-FLANGE FACINGS

NOMINAL PIPE SIZE	DIAMETER FLANGE	DIAMETER BOLT CIRCLE	DIA. RAISED FACE	FLANGE THICKNESS	NO. OF BOLTS	SIZE OF BOLTS DIAMETER
DIM. A	DIM. B	DIM. C	DIM. D	DIM. E		
1	4-7/8	3-1/2	2	11/16	4	5/8
1-1/4	5-1/4	3-7/8	2-1/2	3/4	4	5/8
1-1/2	6-1/8	4-1/2	2-7/8	13/16	4	3/4
2	6-1/2	5	3-5/8	7/8	8	5/8
2-1/2	7-1/2	5-7/8	4-1/8	1	8	3/4
3	8-1/4	6-5/8	5	1- 1/8	8	3/4
3-1/2	9	7-1/4	5-1/2	1- 3/16	8	3/4
4	10	7-7/8	6-3/16	1- 1/4	8	3/4
5	11	9-1/4	7-5/16	1- 3/8	8	3/4
6	12-1/2	10-5/8	8-1/2	1- 7/16	12	3/4

Table No. 5

600-POUND CAST-STEEL VALVES AND FITTINGS
DIMENSIONS OF AMERICAN STANDARD STEEL-FLANGE FACINGS

NOMINAL PIPE SIZE	DIAMETER FLANGE	DIAMETER BOLT CIRCLE	DIA. RAISED FACE	FLANGE THICKNESS	NO. OF BOLTS	SIZE OF BOLTS DIAMETER
DIM . A	DIM. B	DIM. C	DIM. D	DIM. E		
1	4-7/8	3-1/2	2	11/16	4	5/8
1-1/4	5-1/4	3-7/8	2-1/2	13/16	4	5/8
1-1/2	6-1/8	4-1/2	2-7/8	7/8	4	3/4
2	6-1/2	5	3-5/8	1	8	5/8
2-1/2	7-1/2	5-7/8	4-1/8	1- 1/8	8	3/4
3	8-1/4	6-5/8	5	1- 1/4	8	3/4
3-1/2	9	7-1/4	5-1/2	1- 3/8	8	7/8
4	10-3/4	8-1/2	6-3/16	1- 1/2	8	7/8
5	13	10-1/2	7-5/16	1- 3/4	8	1
6	14	11-1/2	8-1/2	1- 7/8	12	1

NOTE: The above tables of dimensions also apply to forged steel flanges.

Screwed Fittings

Screwed fittings (Fig. 103) are usually made of cast iron or of malleable iron, and are galvanized when used on cold-water systems. When they are used for hot-or salt-water systems, screwed fittings are generally made of bronze. The purpose and uses of screwed fittings are the same as those of flanged fittings. The chief difference is that connections are made with male and female threads instead of with bolts. The following sketches show a few common screwed fittings:

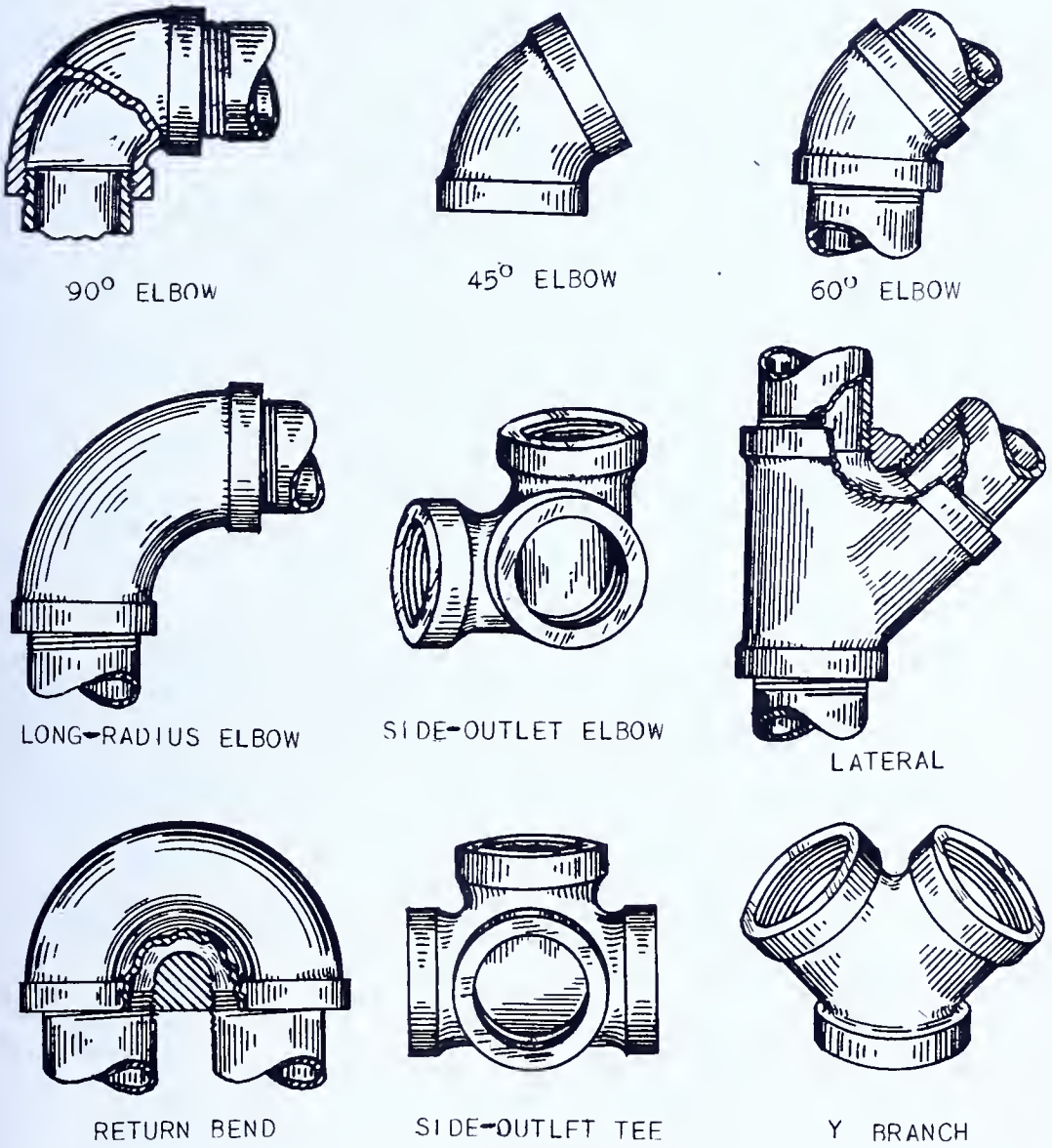


Fig. 103 — *Screwed Fittings*

Reducing Fittings (Screwed)

It is essential that the marine pipefitter knows how to read reducing fittings. In the following figures of reducing fittings each opening is identified with a letter which indicates the sequence to be followed in reading the size of the fitting.

A reducing fitting is one that has a larger size at one end than at the other. Some have tried to establish the term "increaser", thinking of the direction of the flow. This has been due to a misunderstanding of the trade customs of always giving the largest size of run of a fitting first, hence all fittings having more than one size are reducers.

Specifying Reducing Fittings — When fittings are used to connect more than one size of pipe, the size of the largest-run opening is given first, followed by the size at the opposite end of the run. The diagrams in Figs. 104 and 105 show the order of specifying reducing fittings. The word "male" must follow the size of the opening if an external thread is wanted.

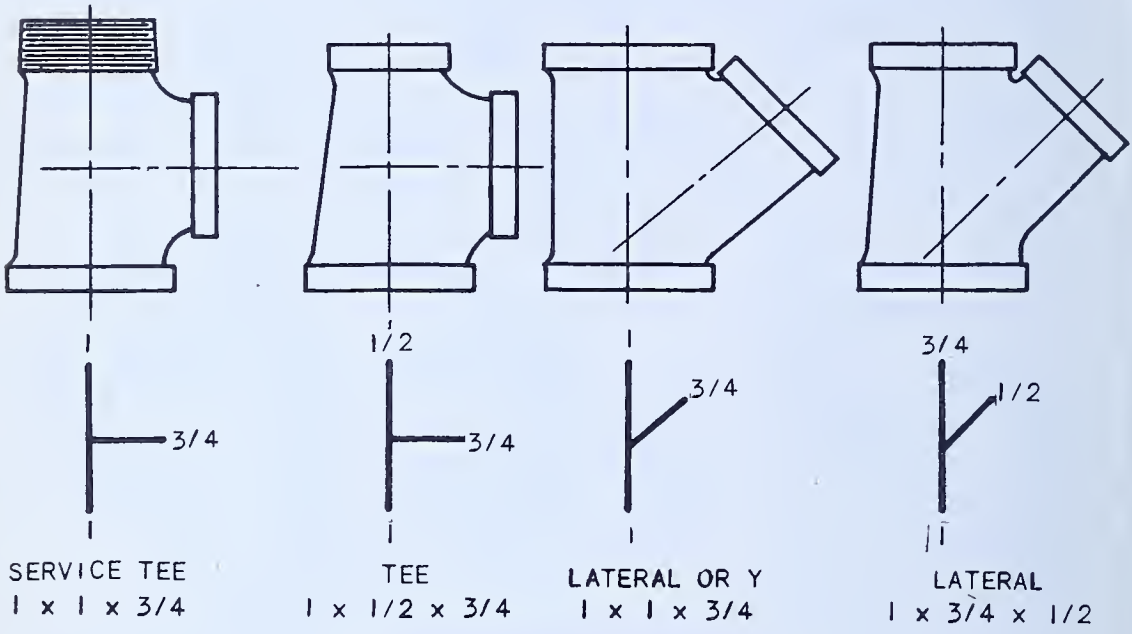


FIG. 104 — *Specifying Fittings*

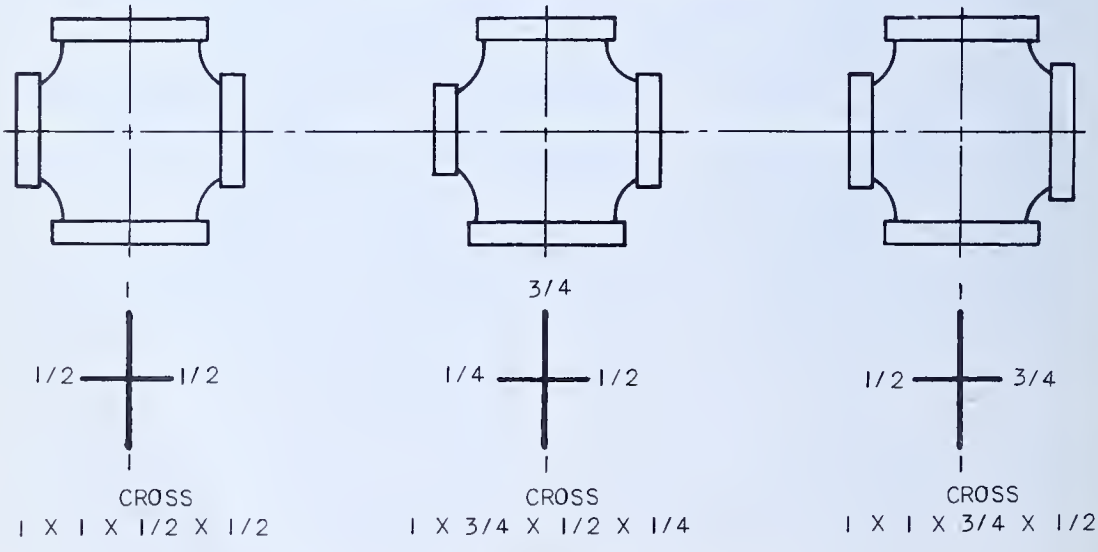


FIG. 105 — *Specifying Fittings*

The accompanying sketches in Fig. 106 show a number of screwed fittings and the order in which the opening sizes are to be read (*A*, *B*, *C*, etc.).

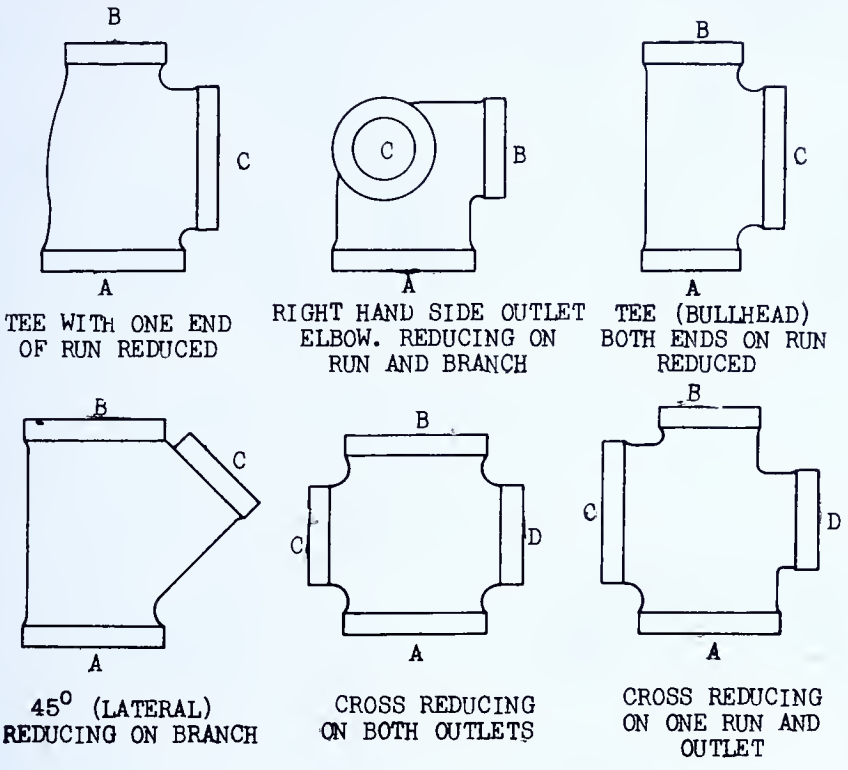


FIG. 106 — *Order of Reading Opening Sizes*

WELDED FITTINGS

Standard weld fittings, such as 90°, 60°, and 45° ells, tees, reducers, flanges, etc., are constructed of a good grade of steel and are forge-made. Modern marine pipe-fitting demands the use of a considerable amount of weld fittings on piping jobs.

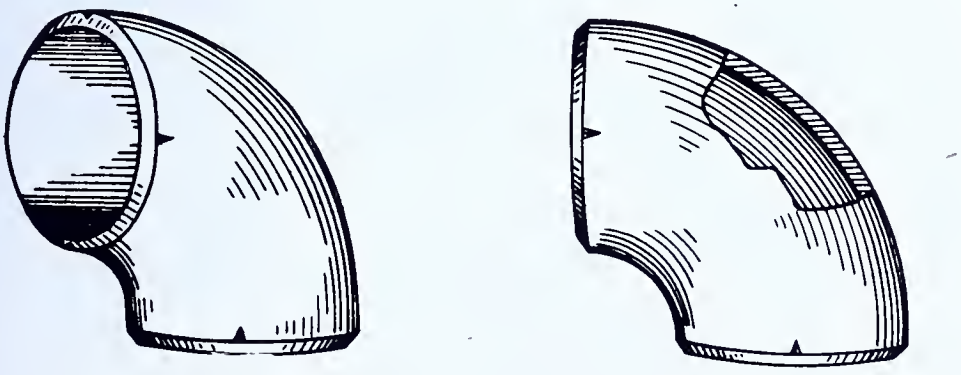

SEAMLESS-STEEL WELDED ELL SHOWING BEVELED ENDS
ELL SHOWING THE PATENTED QUARTER-MARKS WHICH AID IN LAYOUT WORK AND LINING UP

FIG. 107 — *Steel Fittings*

The ends of these fittings are machine-beveled to insure a squareness and easy and quick installation. Figure 107 shows a seamless-steel, welded ell.

Other seamless-steel welding fittings are shown in Figs. 108 and 109.

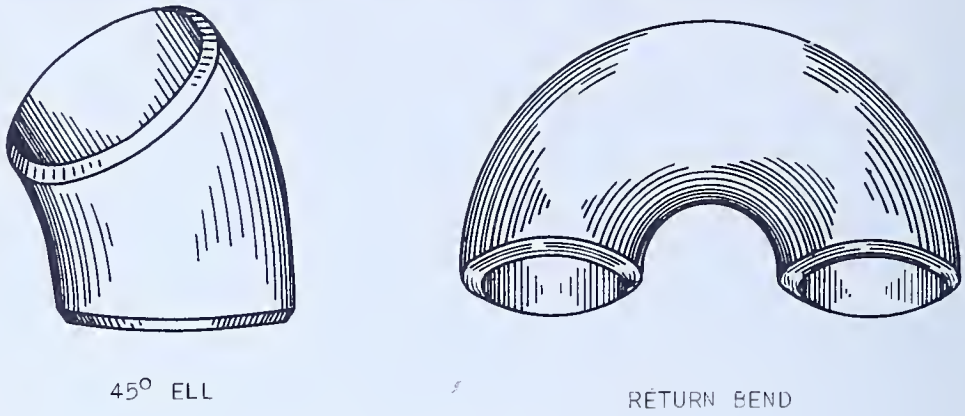


FIG. 108 — *Steel Fittings*

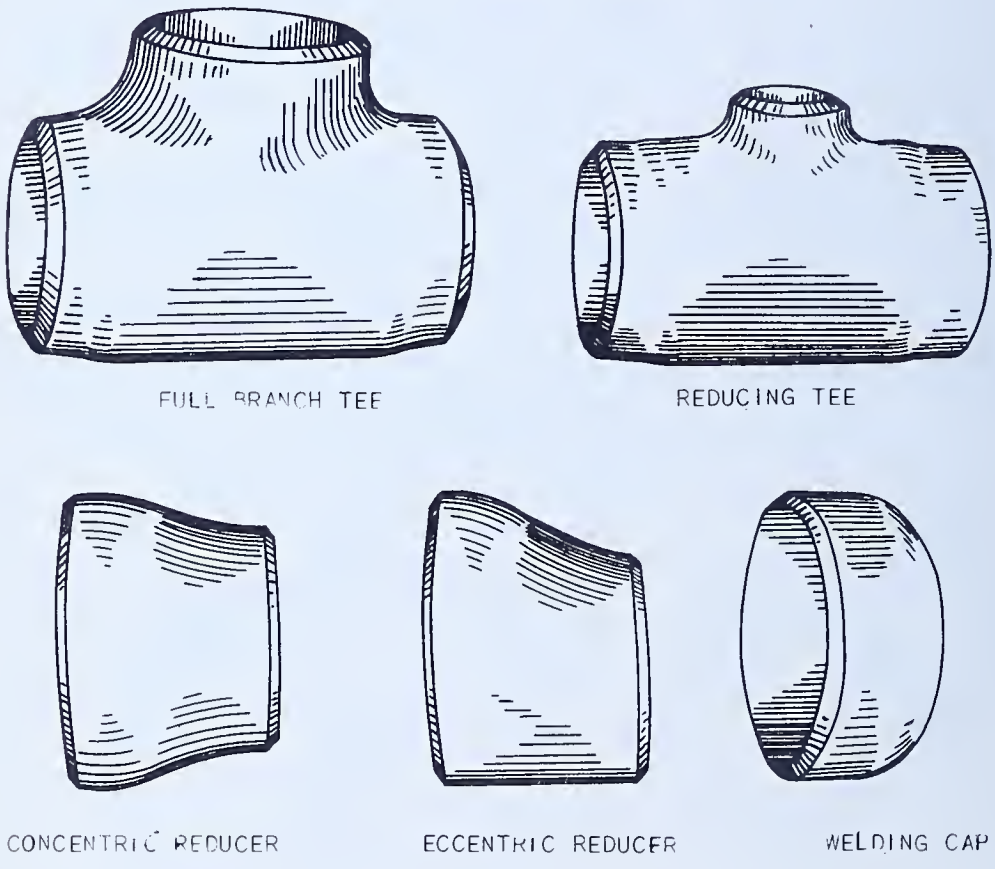


FIG. 109 — *Steel Fittings*

Figures 110 and 111 illustrate the difference between a welded-pipe assembly and a screwed-pipe assembly.

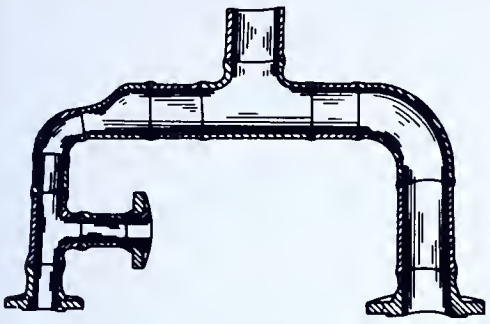


FIG. 110 — *Welded-Pipe Assembly*

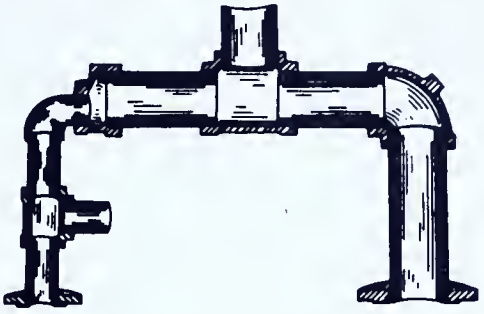


FIG. 111 — *Screwed-Pipe Assembly*

One distinct advantage of using a welding fitting compared with welding a branch into a main line is shown in Fig. 112, *A* and *B*. When welding a branch into a main line, sharp, rough corners result, and slag accumulates in the pipe *A*. When a welding fitting is used as in *B*, the passages are free from slag and welds, because the welder does not need to fill the gaps caused by uneven template cuttings.

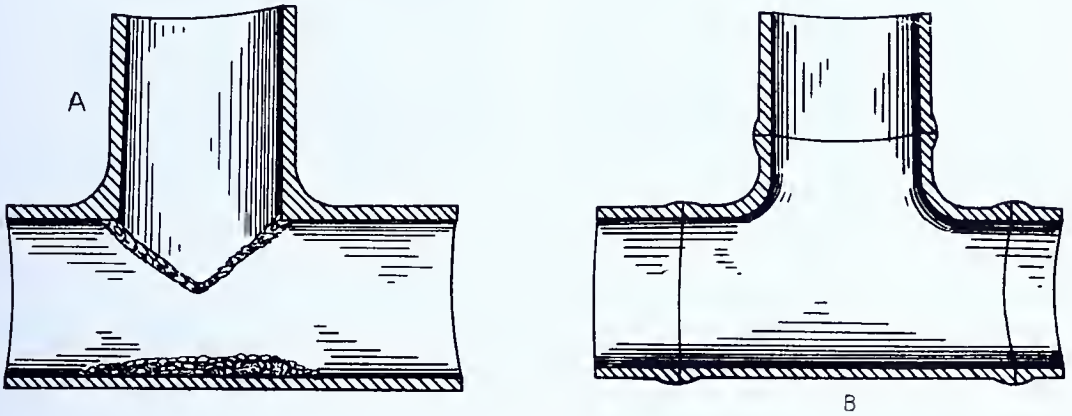


FIG. 112 — *Welded Fittings*

CHILL RINGS (FIG. 113)

A chill ring is made of thin steel and has a collar on each side that fits the inside diameter of the pipe in which it is to be used. A chill ring is used only on butt-welded jobs as shown in Fig. 114.

The primary purpose of the chill ring is to eliminate the formation of "icicles" which later may become loosened and cause trouble in valve seats. Another reason is to insure a true butt joint.

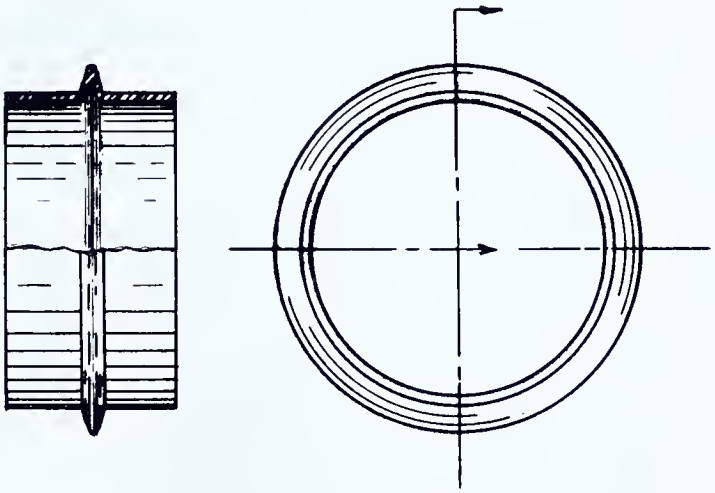


FIG. 113 — *Chill Ring*

Socket-Welding Fittings

The socket type of weld has certain advantages over the butt weld that recommends it strongly for the smaller sizes of pipe lines. The pipe used with it does not require a beveled edge, and since the pipe end slips into and is supported by the socket, the joint is self-aligning. This condition eliminates the use of special clamps and tack welding. Due to the fact that the weld is on the outside surface of the pipe, there is no danger of welding icicles, or beads forming on the inside of the pipe which would restrict the flow and clog the line.

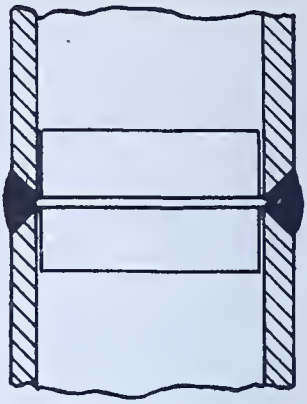


Fig. 114 — *Chill Ring Used in a Butt-Weld*

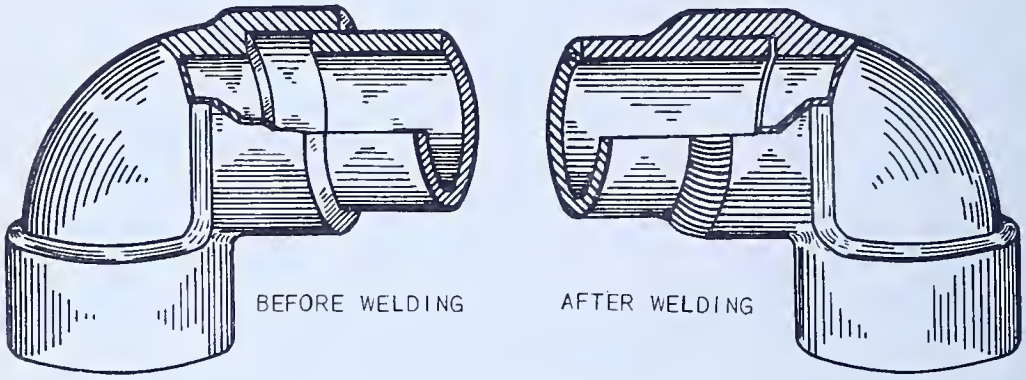


Fig. 115 — *Socket-Welding Fittings*

Centring Fittings

These Centring fittings have patented features that improve upon ordinary welding fittings. It will be noticed in the sketch that the need for chill rings is eliminated. The formation of icicles will be almost impossible. Then too in ordinary butt-welded fittings, a great deal of time must be spent to align the adjoining parts so that a true butt joint is made. The component parts of the Centring fitting and the pipe, fit together snugly and accurately; that is, they are practically self aligned.

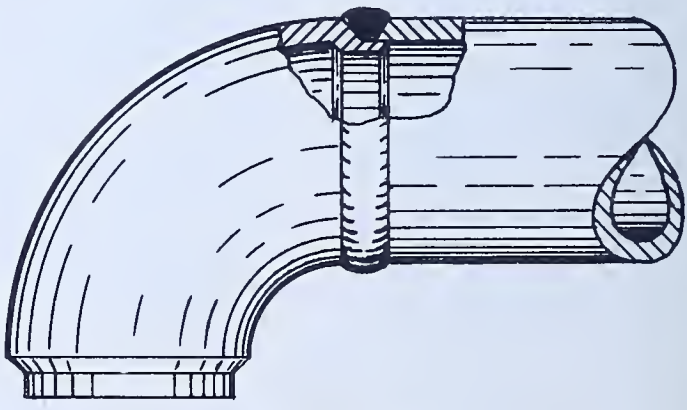


Fig. 116 — *Centring-Welded Fitting*

Unions

A union is a fitting used to connect pipe. It commonly consists of 3 pieces: the threaded end, fitted with exterior and interior threads; the bottom end, fitted with external threads and a small exterior shoulder; and a ring which has an inside flange at one end, and at the other end an inside thread like that on the exterior of the thread end.

Unions are extensively used, as they permit connections with very little disturbance of the pipe position. A female type of union is shown in Fig. 117. The ground joint insures a leak-proof connection and eliminates the necessity for a gasket.

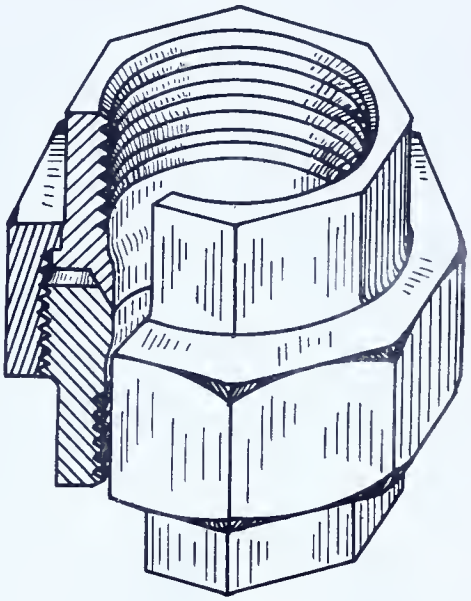
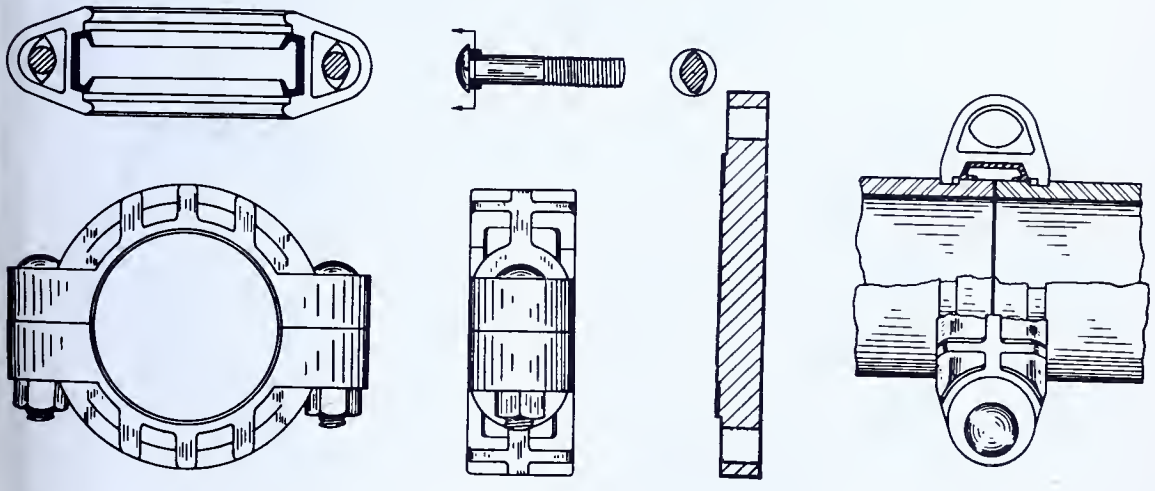


Fig. 117 — *Female Type of Union*

Victaulic Coupling

These couplings are quickly and easily assembled. Their use is restricted to low pressure systems. The pipe must be grooved by machine before these couplings can be used. A rubber insert is used in connection with the couplings in order to make the seal watertight. The coupling is made of two halves hollowed inside for the rubber insert and with a ring on each end that fits into the groove in the pipe. (Fig. 118 at *A*). A joint is made by slipping the rubber insert over the end of one of the pipes, mating the adjoining pipe, slipping the rubber insert over the joint, clamping the two forged-steel halves into the grooves and then tightening the two halves together with the two bolts. This forms a strong union. Fig. 118 at *B*.



A — *Victaulic Coupling Detail* *B* — *Victaulic Coupling Joint*

Fig. 118 — *Victaulic Coupling*

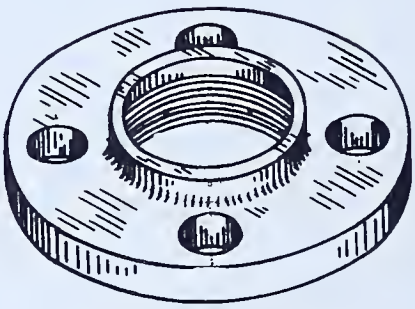
Railing Fittings

Railing fittings, Fig. 119, are usually made of galvanized malleable iron but when they are assembled by welding, steel is used. They are available in many sizes, but the sizes generally used for railing work are from 1 to 1¼ inches. They are used to connect piping which is erected as a permanent guard at various locations on the ship. Handrails for ladders, handrails at the edge of the deck, and handrails for catwalks are a few of the more important uses for railing fittings.

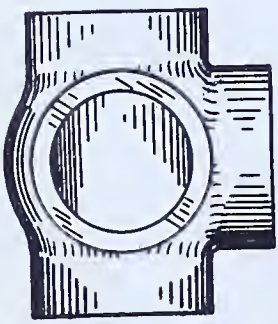
Where handrailing is necessary in the vicinity of the ship's compass, the rail and its fittings are made of brass to eliminate the possibility of deflecting the compass needle on account of close proximity to iron.

90° ELBOW

90° SIDE-OUTLET ELBOW



ROUND FLOOR FLANGE



SIDE-OUTLET TEE

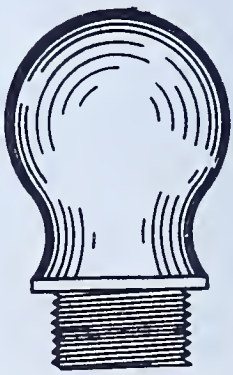


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Fig. 119 — *Railing Fittings*

The table, No. 6, which follows, gives the dimensions of some railing fittings, and the diagrams in Fig. 120 indicate where the dimensions apply to the fittings.

Table No. 6

SIZE	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4
A	1-1/8	1-5/16	1- 1/2	1-3/4	1-15/16	2- 1/4	2-11/16	6- 1/8	3-15/16
E	2	2-1/2	2-11/16	3-3/8	3- 3/4	4-11/16	5- 3/4	6-15/16	8-13/16
G	1-1/2	1-7/8	2- 1/16	2-1/2	2-13/16	3- 7/16	4- 5/16	5- 3/16	6- 5/8

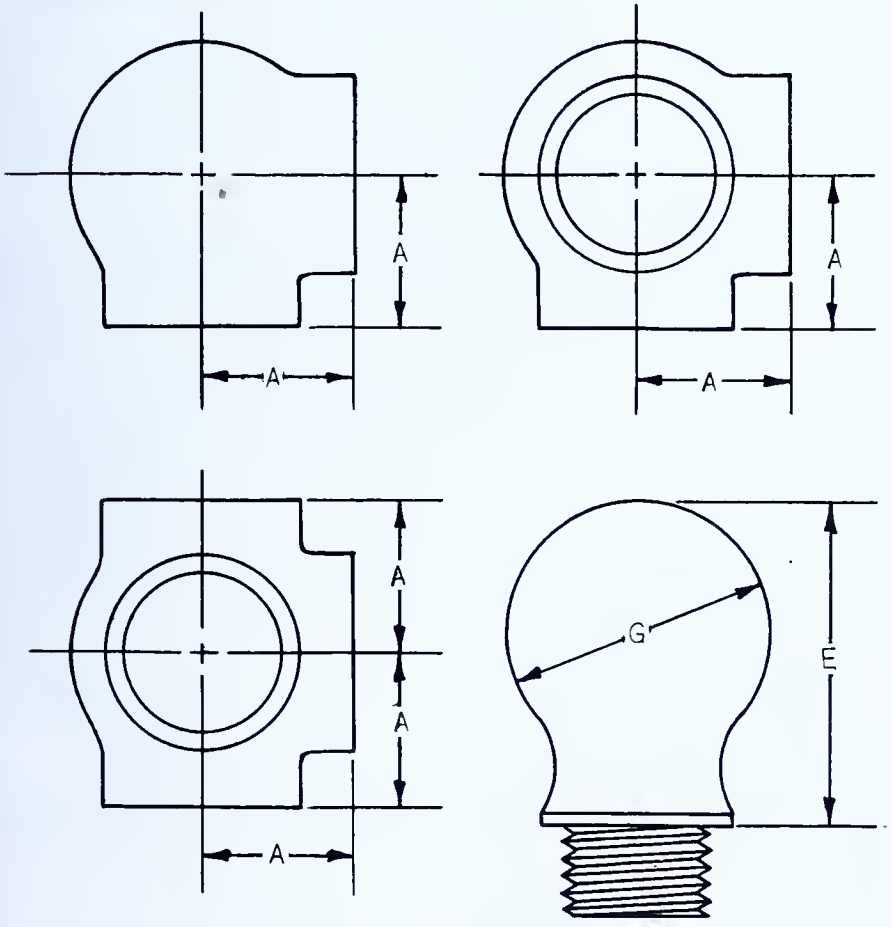
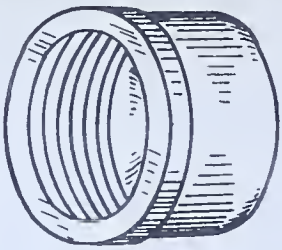


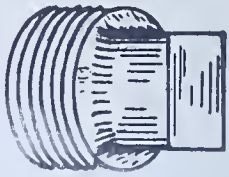
FIG. 120 — *Dimensions of Railing Fittings*

Pipe Plugs and Connections

When a pump or a fixture has been disconnected for removal, the pipe connections should be stopped (plugged) to eliminate the possibility of water, oil, or steam escaping if someone should open the control valve.



A *Pipe Cap*



B *Pipe Plug*

Fig. 121

Figure 121 *A* shows a cap which is used on the male threads of a pipe and a pipe plug *B* used in female threads. The cap or plug also protects the thread from injury. In cases where the end of the pipe is open in a vertical position it is good pipefitting practice to plug the end to prevent trash from getting into the line.

Fig. 122 — *Short Nipple*

Fig. 123 — *Close Nipple*

Figure 122 shows a short nipple. It is the shortest nipple made with a pipe shoulder remaining. Figure 123 shows a close nipple which has no shoulder. A close nipple is not so strong as a short nipple because it is all-threaded on the exterior diameter. A long nipple, as shown in Fig. 124, may be any length from "short" to 12 inches in length.

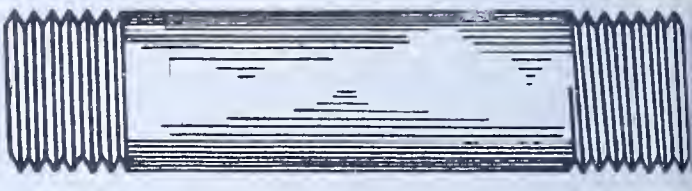


Fig. 124 — *Long Nipple*

QUESTIONS

1. **Name nine commonly used shapes or forms of fittings.**
2. **What three kinds of fittings are used?**
3. **Give one possible advantage of using welding fittings rather than screwed fittings.**
4. **Name several methods of aligning welding fittings for welding.**
5. **Explain the term "Union".**
6. **What is the fundamental difference between railing fittings and ordinary fittings?**
7. **What difference is there between a short nipple and a close nipple?**

INFORMATION SHEET NO. 3
FLANGED JOINTS: TYPES AND USES

Pipe Flanges

The ends of the pipes and the fittings in many pipe line assemblies are connected by *flanged joints*. A flanged joint consists of the flanges on the ends of the pipes or fittings, a gasket between the flanges, and a number of bolts that pass through the circumferences of the flanges and which are pulled up tightly to prevent leakage. A typical flanged joint is shown in Fig. 125.

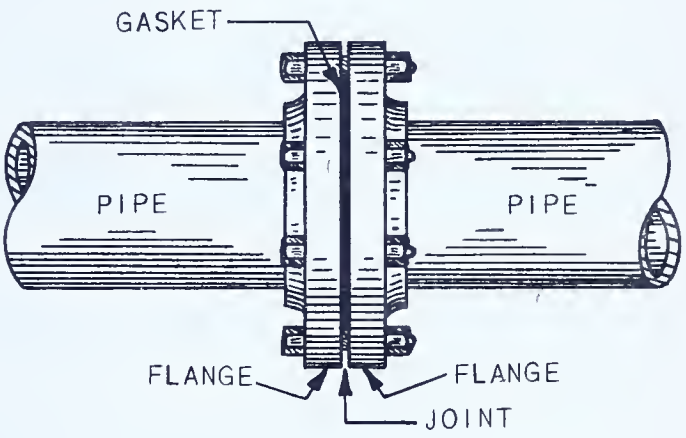


Fig. 125 — *Typical Flanged Joint*

Pipe Flange Standards

The thickness of the flange is determined by the pressure and diameter of the pipe on which it is to be used. The number of bolt holes in a flange and the diameters of the holes are determined by the pressure which the joint must withstand, as well as the size of the pipe and pressure on which the flange is to be used. A close study of the pipe flanges found in the store room or in the shop will reveal that there are many types, and that each type is in a class by itself. Since all manufacturers use the same dimensions when making pipe flanges, a 10″ pipe flange, for example, is always found to have the same number and diameter of bolt holes and to have the same inside and outside diameter and thickness. This is what is meant by the term *Standard*.

Types of Pipe Flanges

The types of pipe flanges commonly used for piping aboard ship are given as follows:

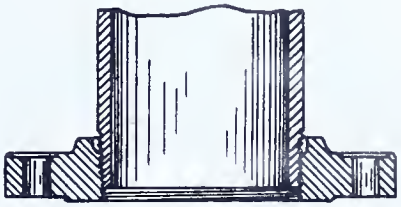


Fig. 126 — *Screwed Flange on End of Pipe*

Screwed Flanges

Screwed flanges have the center holes threaded to fit standard pipe threads. The threads are machined just the right diameter to allow the end of the pipe to come almost flush (even) with the face of the flange as shown in Fig. 126.

The screwed pipe flange shown in Fig. 127 has bolt holes drilled to standard size and spacing.

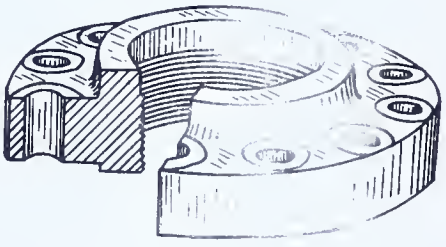


Fig. 127 — *Screwed Pipe Flange*

Note the spot-faced surfaces around the bolt holes. The cross section of the flange, Fig. 128, shows the spot-facing around the bolt holes which allow the bolt heads and nuts to seat fairly and not cause the bolts to "cramp" when the nuts are drawn down tightly.

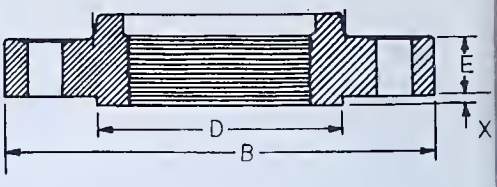


FIG. 128 — *Screwed Pipe Flange Cross Section. For Dimensions see Table Nos. 3, 4, and 5.*

WELDED FLANGES (SLIP FLANGE)

Welded pipe flanges are usually forged steel. They are bored out to slip on the end of the pipe and are then welded inside and outside as shown in Fig. 129. Room must be allowed for welding on the inside. Figure 130 shows a forged-steel pipe flange ready to be slipped over the end of the pipe and welded into position as shown in Fig. 129.

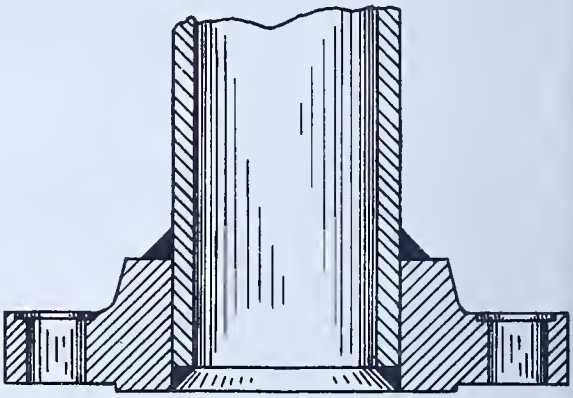


FIG. 129 — *Slip Flange Welded to Pipe*

WELDING NECK FLANGES (Sometimes Called Weld Neck)

Another type of pipe flange is shown in Fig. 131. This flange has a long neck which is bored out to fit the diameter of the pipe on which the flange is to be used. On high pressure pipe a chill ring (Fig. 113) is slipped inside of the pipe and the flange, and the "neck" is welded to the pipe as shown in Fig. 132.

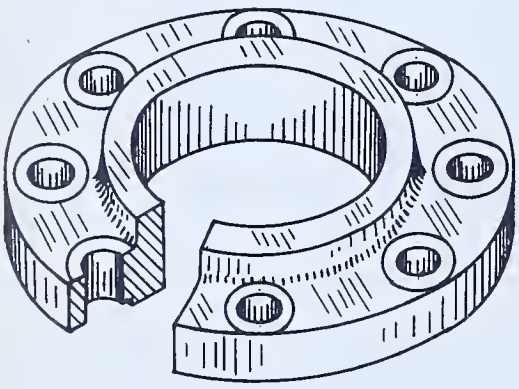


FIG. 130 — *Forged-Steel Slip Flange*

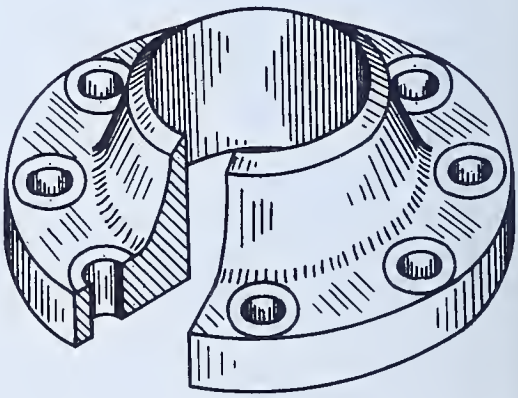


FIG. 131 — *Welding-Neck Flange*

Rolled or Expanded Flanges

The end of the pipe is expanded inside of the flange by rolling. The groove or recess (Fig. 133) on the inside diameter of the hole forms a space into which the wall of the pipe is "pushed" or expanded by means of a special tool. Fig. 134.

An expanded flange joint is used on all kinds of work (steam) where the diameter of the pipe is 2½" or under and when the pressure is under 250 lbs. This type of flanged joint will last longer than the screwed type. Because there is no cutting away of material for threads the full thickness of the pipe wall is retained.

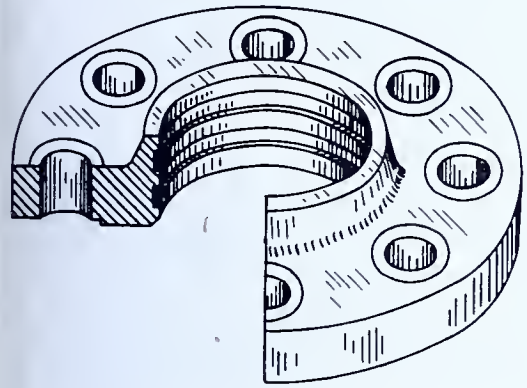


Fig. 133 — *Expanded Flange*

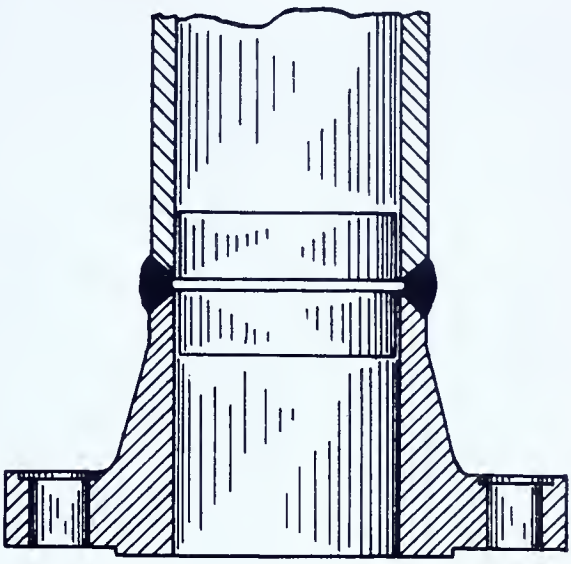


Fig. 132 — *Welding-Neck Flange Welded to Pipe*

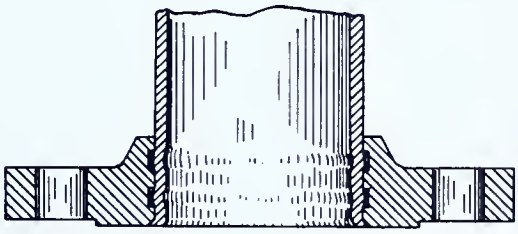


Fig. 134 — *Pipe Expanded Into Flange*

Raised-Face Flange

This type of flange (Fig. 135) is used on high pressure work. The raised face allows the flange to "dish" slightly when the bolts are pulled up. The gasket is "pinched" all around on the outside thus helping to make the job leak proof.

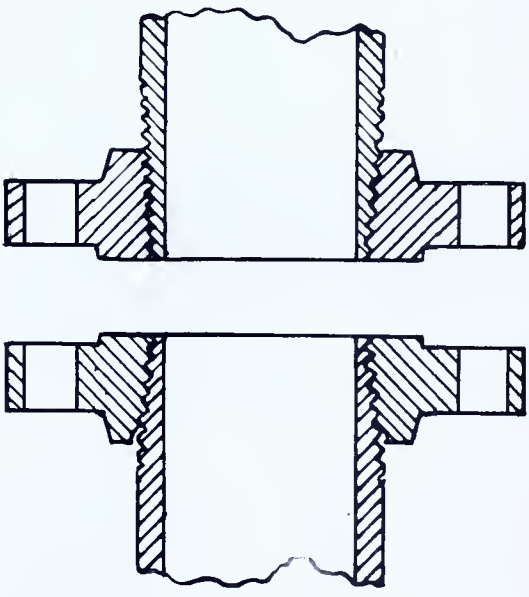


Fig. 135 — *Raised-Face Flange*

Tongue and Groove Flanged Union

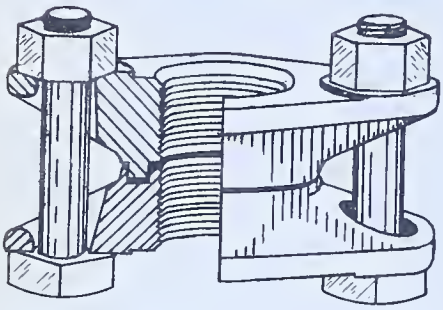


Fig. 136 — *Oval Tongue and Groove*

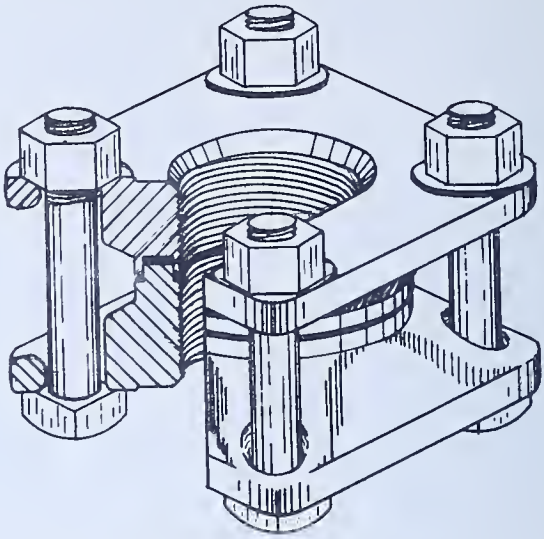


Fig. 137 — *Square Tongue and Groove*

This type of flange union, often called Ammonia Flange, is espccially well adapted for use in close quarters. The two halves fit together in a tongue and groove arrangement. A ring gasket used between the tongue and groove insures a leakproof joint. The gasket cannot blow out because it is confined in the groove. Round, square, and oval forms are available; also a system is in current use whereby an elbow is used as the female member of the flange to eliminate the use of several fittings. This type of joint is used in moderately high-pressure systems and will withstand a great deal of vibration and jarring.

Lap (Van Stone) Joint

This type of flange (138) is used on high-pressure steam lines in ship pipefitting. The value of this type of flange is that it can be turned to any position on the pipe without regard for the position of the bolt holes.

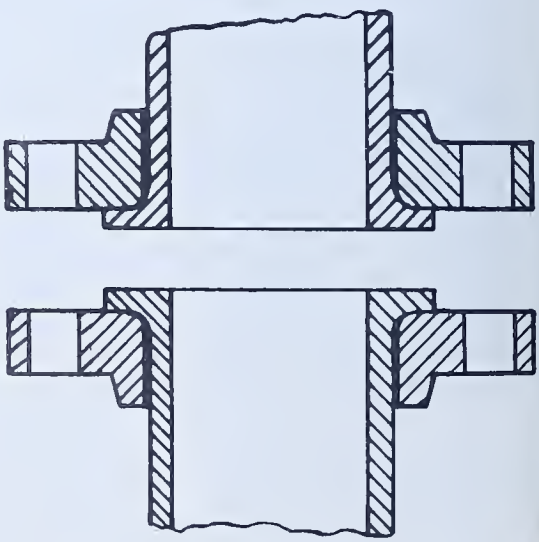


Fig. 138 — *Lap (Van Stone) Joint*

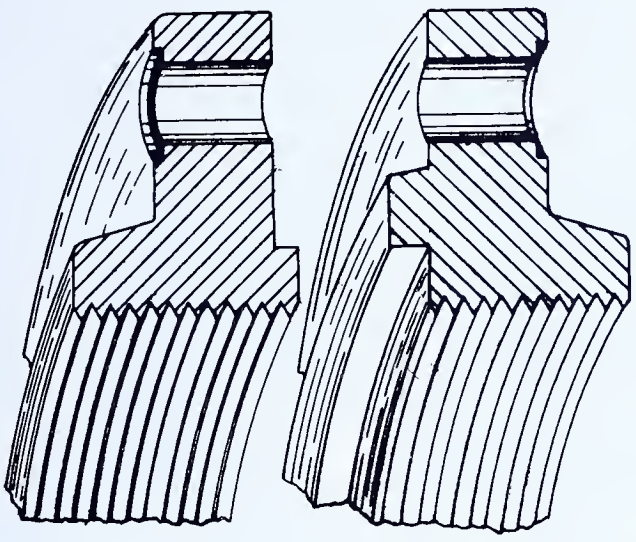


FIG. 139 — *Male and Female Flange*

MALE AND FEMALE FLANGE

This type of flange (Fig. 139) is sometimes used on ammonia and high pressure work. The gasket is compressed between the two flanges and in the recess formed by the female-half of the flange. When the bolts are drawn down tightly the gasket is confined, eliminating the possibility of having it blow out. The cross section in Fig. 140 shows the flanged ends of the two pipes ready for the bolts.

SLIP JOINT

The slip joint (Fig. 141) is used only in plumbing. It is usually used on tubing and eliminates the necessity for a union. It will be seen by the cross section (Fig. 142) that the male thread is on a tube which is large enough on the inside to allow the connecting tube to slip inside snugly. The gasket (or packing) is drawn tightly against the male threaded end and the hexagonal nut is pulled up tightly as it is screwed on to make it a leak-proof joint. An advantage of this type of joint is that the tubing need not be cut to an exact length. The slip feature of the joint allows considerable variation.

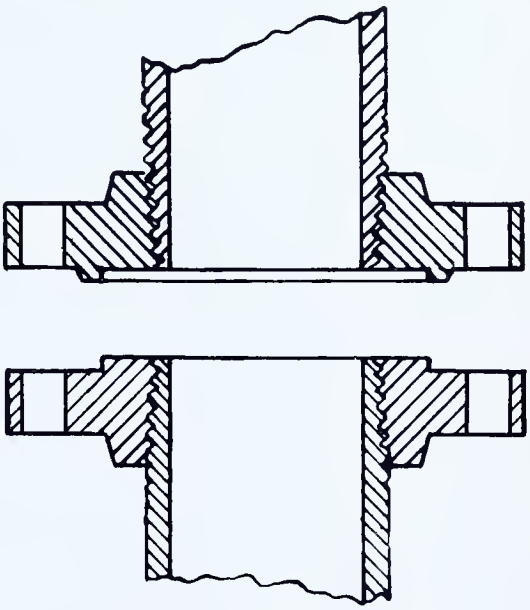


FIG. 140 — *Cross Section Male and Female Flange*

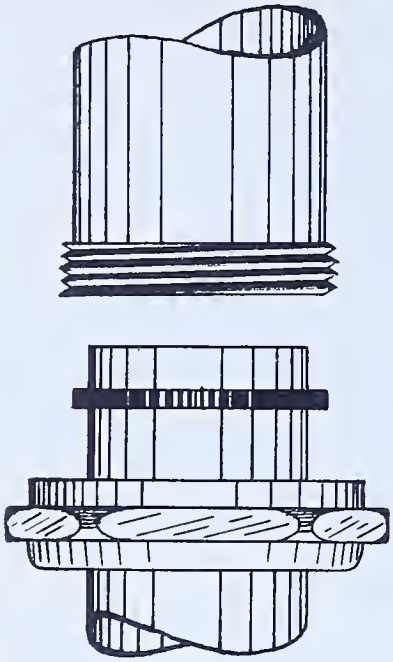


FIG. 141 — *Slip Joint*

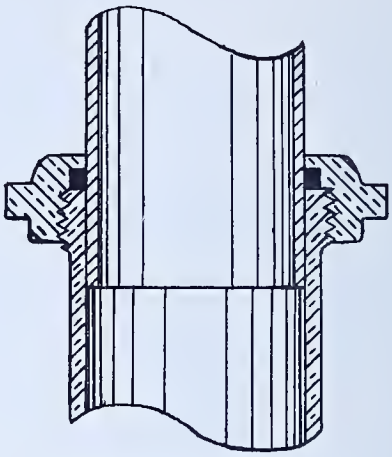


FIG. 142 — *Slip Joint Cross Section*

BLANK (BLIND) FLANGES

Blank flanges are used in the shop to close the ends of assemblies that are being tested. On board ship blind flanges are used to blank off ends of pipes that may have to be used later on. When the line end is to be used, the blank flange can be quickly removed and the additional section can be fastened to the flange on the end. These flanges are available in the same weights and sizes as all other flanges. Facings for blank flanges conform to the standard flange facings of flanged fittings and valves.

Several variations of blank flanges are used in marine piping. Because of the nature of the piping systems aboard ship it if often necessary to install a combination blind and open flange. Flanges of this type are called spectacle flanges because of their resemblance to eye glasses or spectacles. This type of flange is useful when a hasty repair has to be made in one section of a system that is being used. An open line may be blanked off in a few minutes by the use of a spectacle flange. In several systems a special fitting called a positive blank is installed. Fittings of this type are

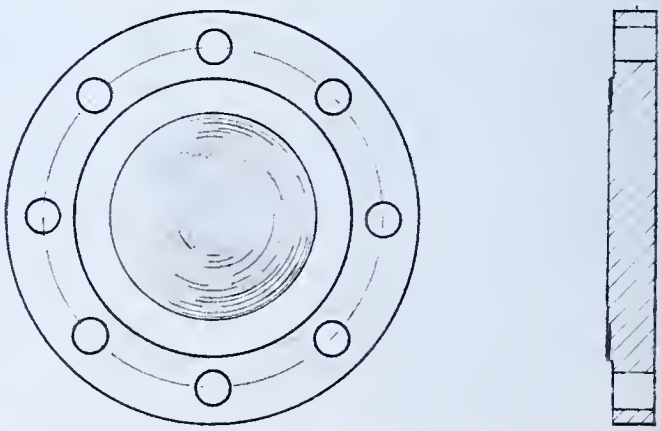


FIG. 143 — *Blank Flange*

opened and closed with a spanner wrench. This arrangement is similar to a turnbuckle. One pipe end is threaded with a right hand thread while the other is threaded with a left hand thread. Turning the body in one direction will spread the ends of the pipe and permit the spectacle to be pulled through until the blind side is in place. The joint is made tight by turning the body in the opposite direction with the spanner wrench. A line may be blanked off in a few minutes by this method.

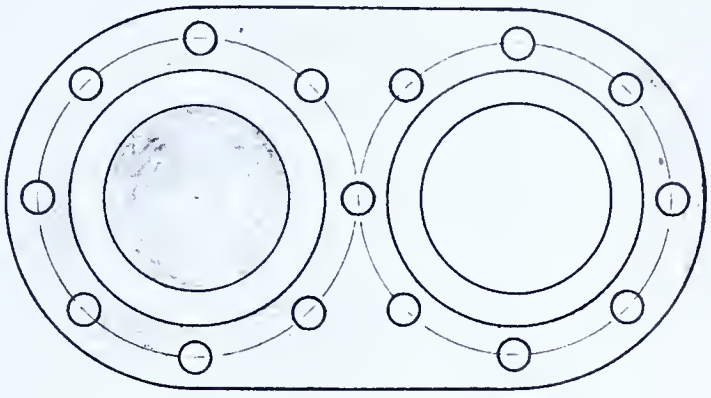


FIG. 144 — *Spectacle Flange*

DUTCHMAN

Sometimes a flanged section of pipe being fitted into place aboard ship will not have true facing surface with the face of the valve, pump, or pipe flange to which it is to be fastened. If the difference is very slight, the flange can be pulled tight and true by the flange bolts. If the difference between faces happens to be $\frac{1}{8}''$ or $\frac{1}{2}''$, some other method will have to be used to true the flange surfaces. For cases like this, a plate is sent to the machine shop to be machined down to the proper size. The illustration shows a sample of the "Dutchman", as the machined flange is called.

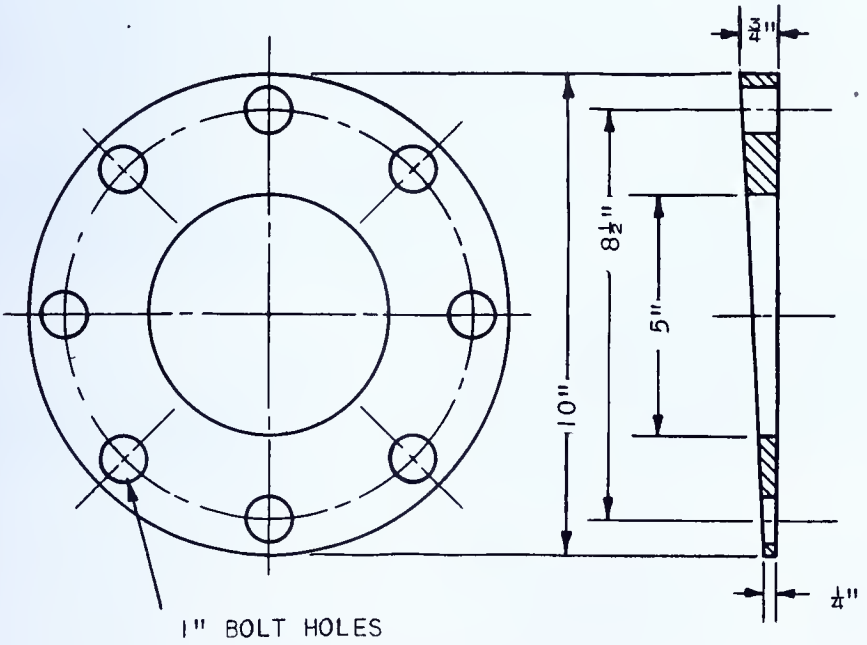


FIG. 145 — *Tapered Dutchman*

QUESTIONS

1. Give an explanation of a pipe flange.
2. Explain the meaning of a flanged joint.
3. What is understood by the term "standard" as applied to pipe and pipe flanges?
4. State the principal difference between the screwed flange and the forged-steel slip flange.
5. What is the chief advantage of a welding-neck flange?
6. At how many places is the welding-neck flange welded to the pipe?
7. What is a chill ring?
8. For what reason is a chill ring used when making a butt weld?
9. Why is a chill ring used in a welding-neck flange butt joint?
10. What is understood by an expanded flanged joint?
11. State the advantage of a raised-face flanged joint.
12. Where, particularly, is a male and female flanged joint used?
13. What is the particular advantage of a Van Stone Flange?
14. Describe an ordinary slip joint.
15. What is the chief advantage of slip-joint construction?
16. State the locations where a slip joint is generally used.

INFORMATION SHEET NO. 4
* VALVES: TYPES AND USES

Globe Valve

Glove valves are used in lines which carry pressure. When the valves are installed correctly, the pressure can be regulated by opening and closing them. A globe valve must always be installed so that the pressure will come against the bottom of the seat. When the valve-stem packing has to be renewed, the valve can be closed tightly and the packing can be replaced without "killing" the line. When the pressure is against the valve seat and not against the packing, the packing will last much longer. The exterior of a typical globe valve is shown in Fig. 146. The same type of valve is shown in cross section in Fig. 147.

Gate Valves

Gate valves are used extensively in low-pressure lines where large volume is required. Because of its construction, the entire valve gate is raised when the valve is opened wide, and the liquid is permitted to flow without any resistance, which is not

Fig. 146 —
Globe-Valve Exterior

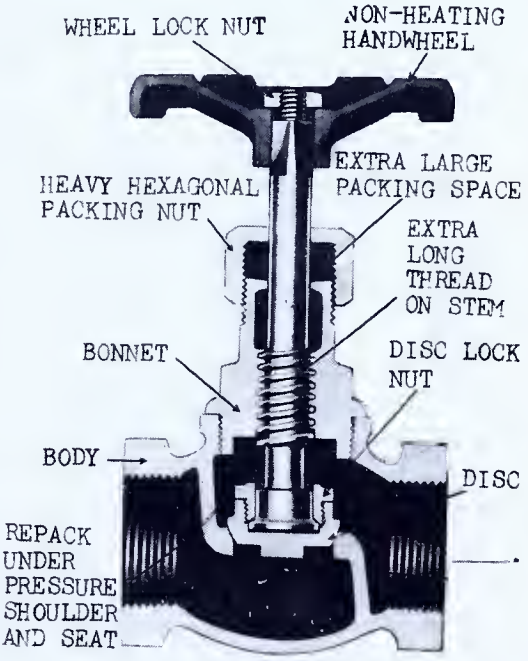


Fig. 147 —
Glove-Valve Cross Section

*Illustrations by Courtesy of The William Powell Company.

the case with globe valves. A gate valve is not required to withstand side pressure. It can be installed quickly and without regard for the direction of flow. It makes no difference on which side the pressure comes.

Gate valves are divided into two classes: rising spindle (stem) and non-rising spindle. The cross section in Fig. 149 shows a rising-spindle type. The reference letters in the figure are explained below.

A. Handwheel
B. Yoke-sleeve nut
C. Yoke sleeve
D. Yoke cap
E. Spindle
F. Yoke
G. Gland
H. Packing box
I. Bonnet
J. Spindle Ring
K. Wedge pin
L. Solid wedge
M. Renewable seat ring
N. Body

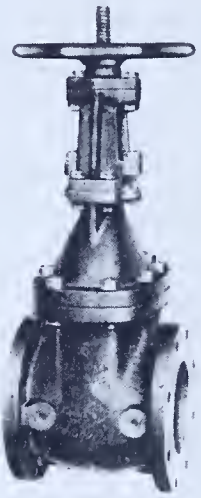


FIG. 148 — *Gate-Valve Exterior*

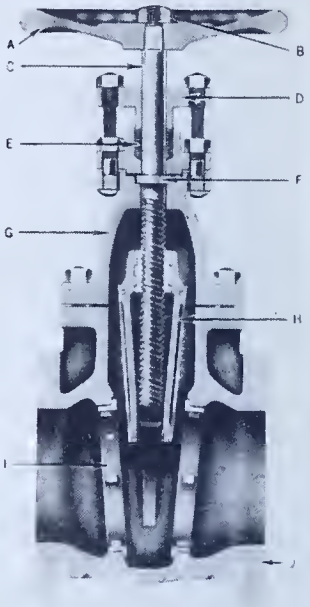


FIG. 149 — *Cross Section of Gate Valve*

Rising-stem gate valves are used in places that are not readily accessible, places that make it difficult to see whether the valves are open or closed. They are used under floor plates or overhead. When the valve is open, the valve spindle projects through the floor and indicates its open position. When the valve is closed, the spindle is concealed by the floor or plate.

A gate valve with a non-rising stem is shown in Fig. 150. Gate valves with non-rising stem are used where it is necessary to open and close the valve with an operating rod. The cross section in Fig. 151 shows the non-rising spindle type.

FIG. 150 — *Exterior of Gate Valve*

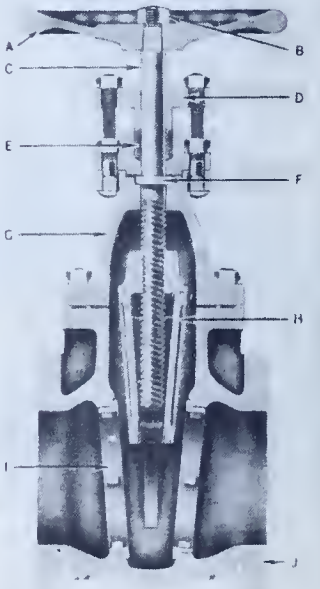


FIG. 151 — *Cross Section of Gate Valve*

The reference letters in the figure are explained below:

A. Handwheel
B. Wheel nut
C. Spindle
D. Gland
E. Packing box
F. Spindle collar
G. Bonnet
H. Solid wedge
I. Renewable seat ring
J. Body

FIG. 152 — *Angle Valve*

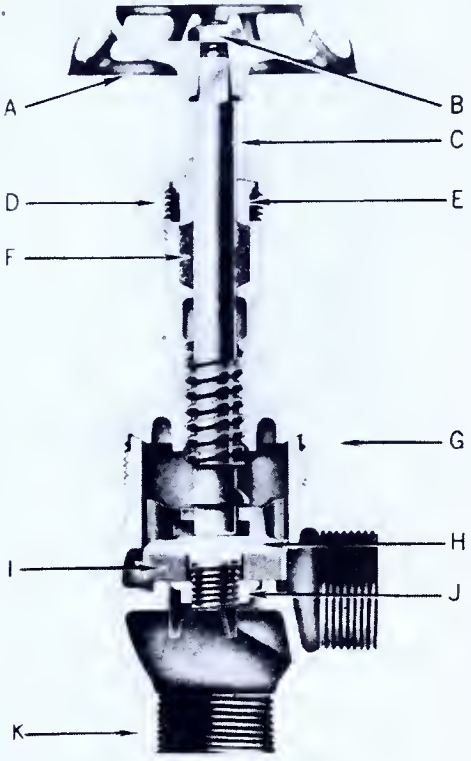


FIG. 153 —
Cross Section of Angle Valve

ANGLE VALVES

An angle valve is used to change the direction of flow in a line without using an extra fitting or without making a bend in the pipe. The angle valve shown in Fig. 152 is for use with a small pipe. Larger angle valves are substantially the same, but are made heavier. The valve action and the construction are practically the same as in a globe valve.

The cross section in Fig. 153 shows the similarity to a globe valve. The reference letters in the figure are explained below:

A. Handwheel
B. Wheel nut
C. Spindle
D. Packing nut
E. Gland
F. Packing box
G. Bonnet
H. Disc holder
I. Renewable composition disc
J. Guide disc nut
K. Body

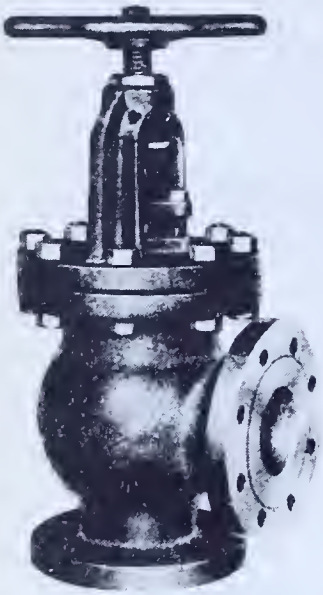


FIG. 154 — *Angle Valve with Flanged Connection*

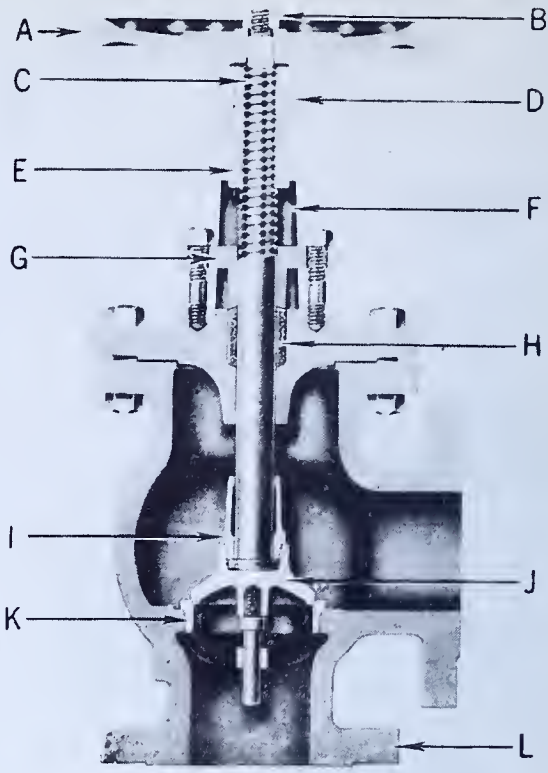


FIG. 155 — *Cross Section of Angle Valve*

FLANGED ANGLE VALVES

A flanged type of angle valve is shown in Figs. 154 and 155. The construction and action of this type of valve is substantially the same as the screwed type.

The reference letters in Fig. 155 are explained below:

A. Handwheel
B. Wheel nut
C. Spindle
D. Yoke-bushing lock nut
E. Yoke bushing
F. Yoke bonnet
G. Gland
H. Packing box
I. Disc lock nut
J. Beveled disc
K. Renewable seat ring
L. Body

CHECK VALVE

Check valves are used in high-pressure or low-pressure lines where the flow must be in one direction only. Check valves are divided into two distinct groups: lift checks and swing checks. The cross section shown in Fig. 157 indicates the nature of a swing check valve.

FIG. 156 — *Swing Check Valve*

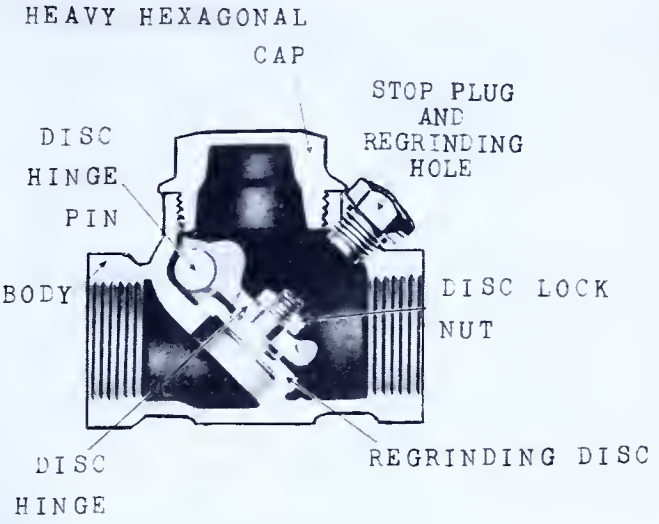


FIG. 157 — *Cross Section of Swing Check Valve*

Lift checks (Figs. 158, 159, and 160) are used in high-pressure lines. Swing checks (Figs. 156, and 157) are used in low-pressure lines where volume is the main factor. Vertical checks and horizontal checks will not permit so great a volume of flow as swing checks.

The reference letters in Fig. 159 cross section are explained below:

A. Bolted cover
B. Beveled disc
C. Renewable seat ring
D. Body

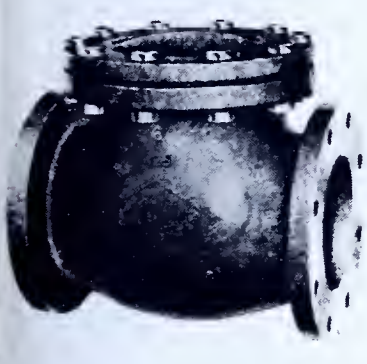


FIG. 158 — *Exterior of Horizontal-Lift Check Valve*

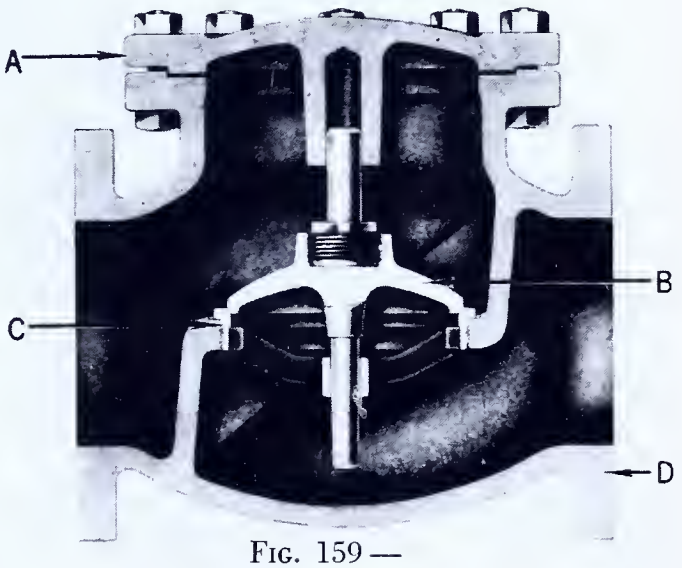


FIG. 159 — *Cross Section of Horizontal-Lift Check Valve*

The reference letters in Fig. 161 cross section are explained below:

A. Bolted cover
B. Stem
C. Disc holder
D. Renewable composition disc
E. Disc plate
F. Renewable seat ring
G. Body

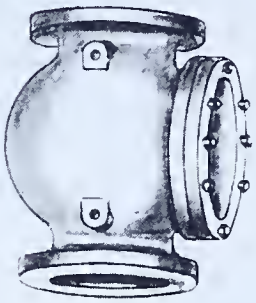


FIG. 160 — *Exterior of Vertical-Lift Valve*

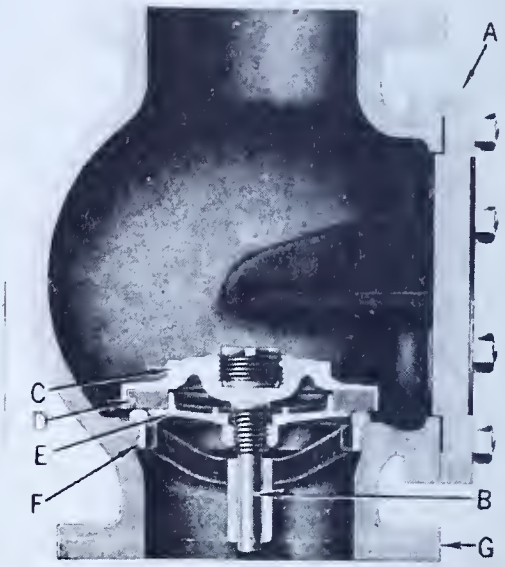


FIG. 161 — *Cross Section of Vertical-Lift Check Valve*

QUICK OPENING

A quick-opening gate valve is what the name implies. By a pull on the lever the valve is entirely opened at once. These valves are mostly used on sounding lines and as vacuum breakers on steam turbines.

FIG. 162 — *Quick-Opening Valve*

NEEDLE VALVE

A needle valve is usually found on gauge lines where the pressure must be regulated to eliminate pump pulsation on the gauge. The needle-like seat permits fine adjustment for a limited flow. Expansion valves on ammonia- and Freon-refrigeration systems are of the needle-valve type.

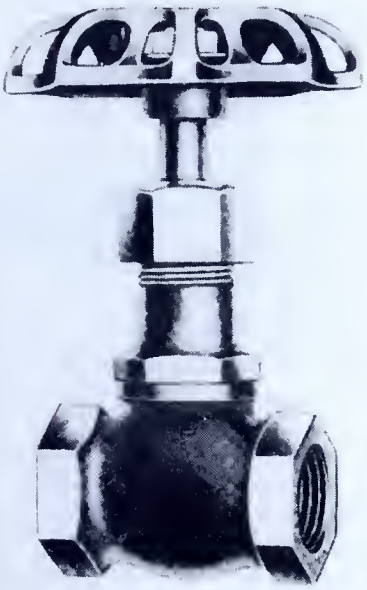


FIG. 163 — *Exterior of Needle Valve*

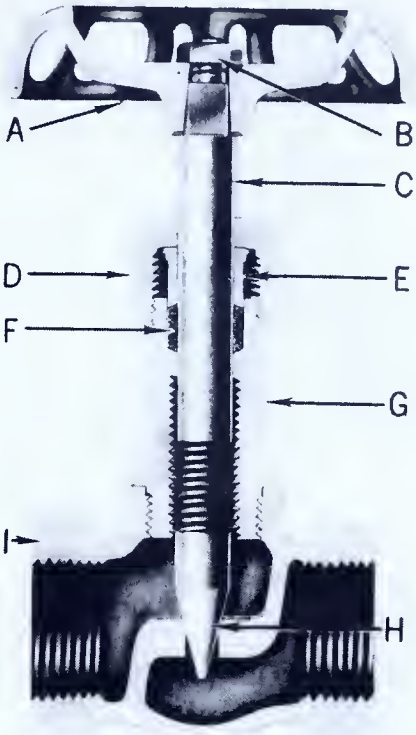


FIG. 164 — *Cross Section of Needle Valve*

The reference letters in Fig. 164 are explained below:

A. Handwheel
B. Wheel nut
C. Spindle
D. Packing nut
E. Gland
F. Packing box
G. Bonnet
H. Needle point
I. Body

RADIATOR VALVES

A radiator valve (Fig. 165) is used to connect the supply line to the radiator by means of a spud (tail piece) screwed into the radiator. The spud has a union collar which fastens to the valve. The union collar eliminates a full union between valve and radiator and thus conserves space.

FIG. 165 — *Exterior of Radiator Valve*

The reference letters in Fig. 166 follow:

A. Black composition wheel
B. Spindle
C. Packing nut
D. Gland
E. Packing box
F. Bonnet
G. Union ring
H. Union nipple
I. Disc holder
J. Composition ring
K. Body

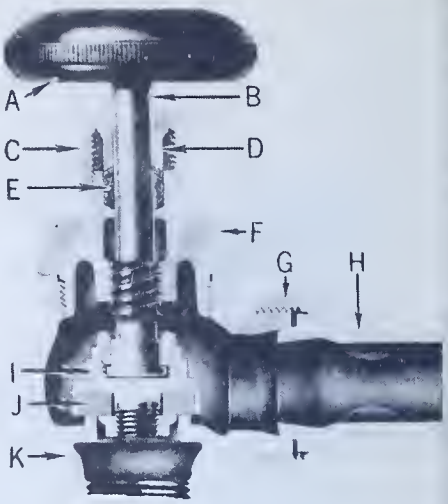


FIG. 166 — *Cross Section of Radiator Valve*

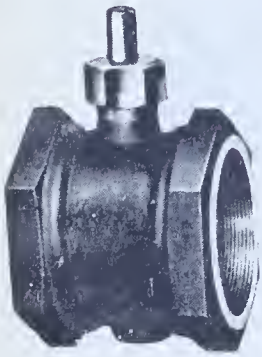


FIG. 167 — *Butterfly Valve*

BUTTERFLY VALVE

A butterfly valve is installed on gas-vent systems. It is not designed to hold pressure or to be watertight. It is made like a damper in a stove pipe.

RELIEF VALVES

The relief valve works almost in an opposite manner to other valves. Instead of regulating the flow of steam or liquids it opens automatically when the pressure on the line exceeds the set pressure of the valve.

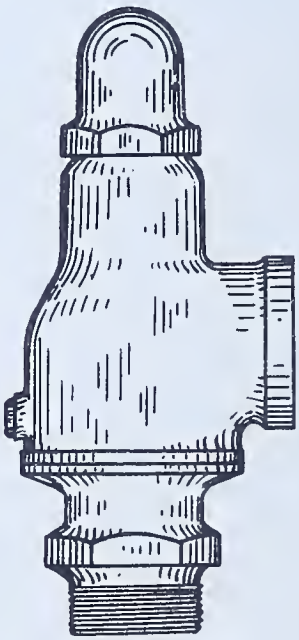


FIG. 168 — *Exterior of Relief Valve*

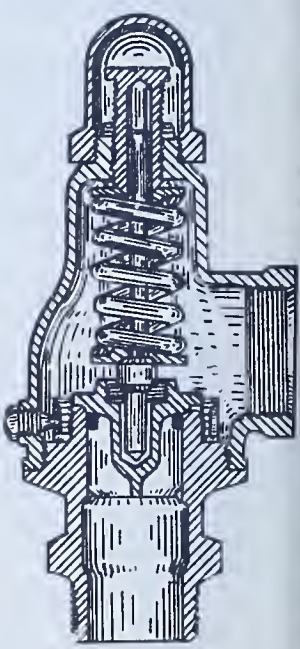


FIG. 169 — *Cross Section of Relief Valve*

Fire Valve

A fire valve derives its name from its purpose; it is a convenient fire-hose connection. The line side may be screwed or flanged. The opposite end is threaded for fire-hose connections.

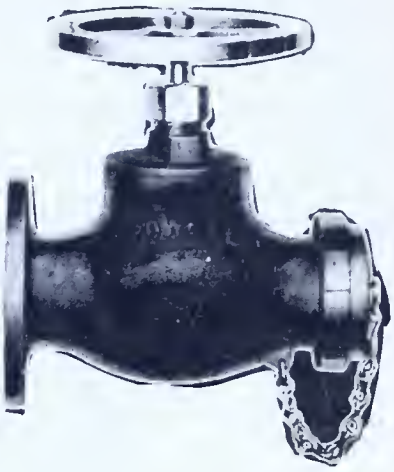


Fig. 170 — *Fire Valve*

Manifold Valve

A manifold (many openings) is a group of valves made into one casting for the specific purpose of saving space. (Fig. 171). The shapes and sizes of manifolds vary with the purpose for which they are to be used. Single manifolds are used on suction lines and discharge lines. Double manifolds are used only on suction lines. When a line is equipped with the double type of manifold, it is possible to fill one compartment and pump out another at the same time.

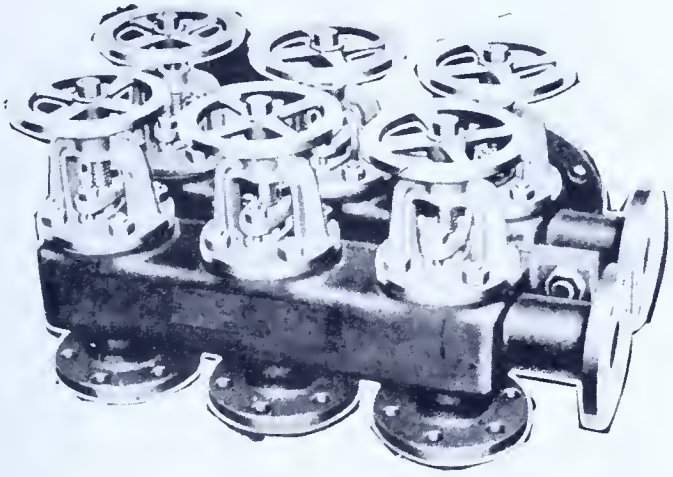


Fig. 171 — *Typical Manifold (Double Type)*

Plug Cock

A plug cock (Fig. 172) is a valve that has been designed for quick service. If the flow of liquid must be shut off or diverted suddenly, a quick turn of the plug cock handle is all that is required. Placing this type of valve in a line eliminates the necessity for tees or extra valves. It affords an unin-

Fig. 172 — *Plug Cock*

terrupted flow which may be abruptly stopped. The plug cock retains its tight, leak-proof seal for a longer period than the ordinary disc-seat valve.

Y Valve (or Blow-Off Valve)

A blow-off valve (Fig. 173) is used in pipe lines where mud and grit are present (boiler mud drums). Its construction permits an almost uninterrupted flow, but still retains its ability to seat tightly under high pressure. The valve-seat disc is made of composition which keeps it from being cut easily by scale or grit.

The reference letters shown in the cross section (Fig. 174) are explained below:

A. Handwheel
B. Wheel nut
C. Spindle
D. Yoke-bushing lock nut
E. Yoke bushing
F. Yoke bonnet
G. Gland
H. Packing box
I. Disc-holder lock nut
J. Disc holder
K. Renewable composition ring
L. Disc plate
M. Disc-plate nut
N. Renewable seat ring
O. Body

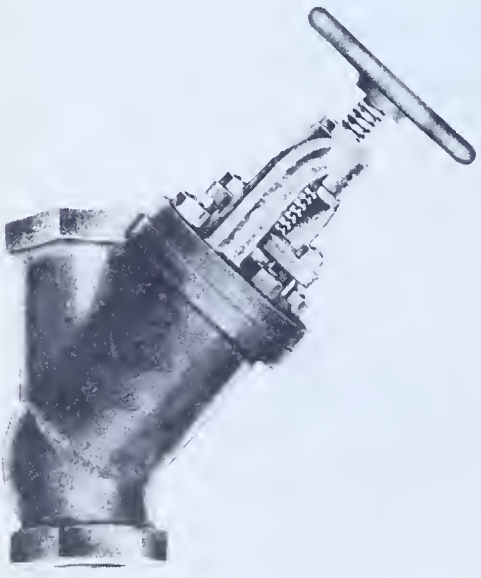


Fig. 173 — *Blow-Off Valve Exterior*

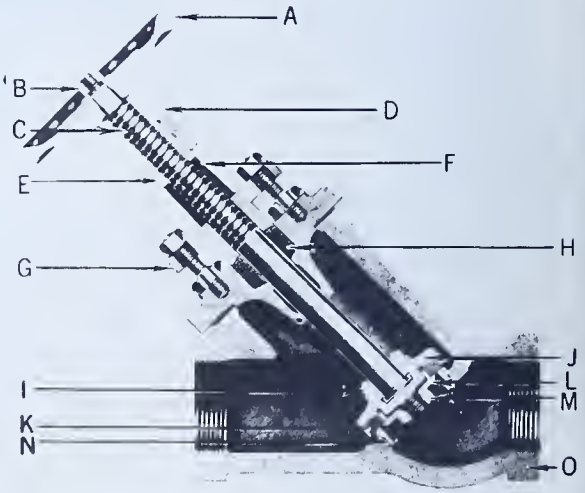
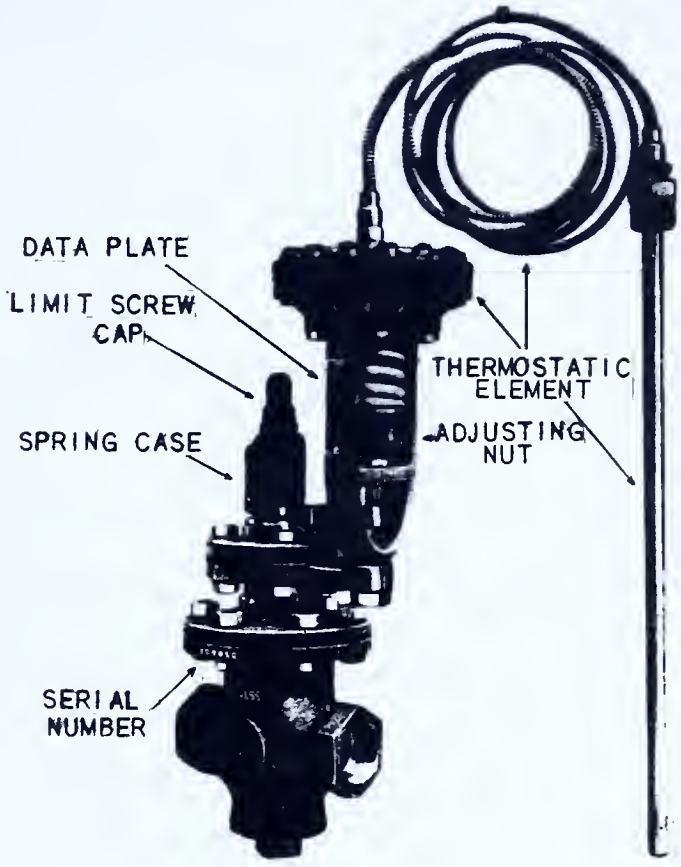


Fig. 174 — *Cross Section of Blow-Off Valve*

(Automatic) Temperature-Control Valves

A temperature-control valve (Fig. 175) is installed where it is necessary to maintain a constant temperature. When a cold liquid is pumped into a tank, it is heated when necessary by steam passing through heating coils. A device operated by the expansion and contraction of a mercury element in the temperature-control valve in the pipe line regulates the amount of steam entering the coils and thus maintains a constant temperature. The valve can be regulated to respond to various degrees of temperature.



Governor Valve

A governor valve (Fig. 176) is used to control the amount of pressure on a pump. The pump

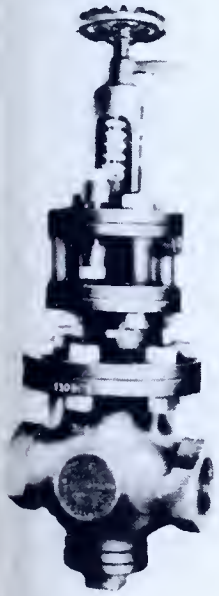


Fig. 176 — *Governor Valve*

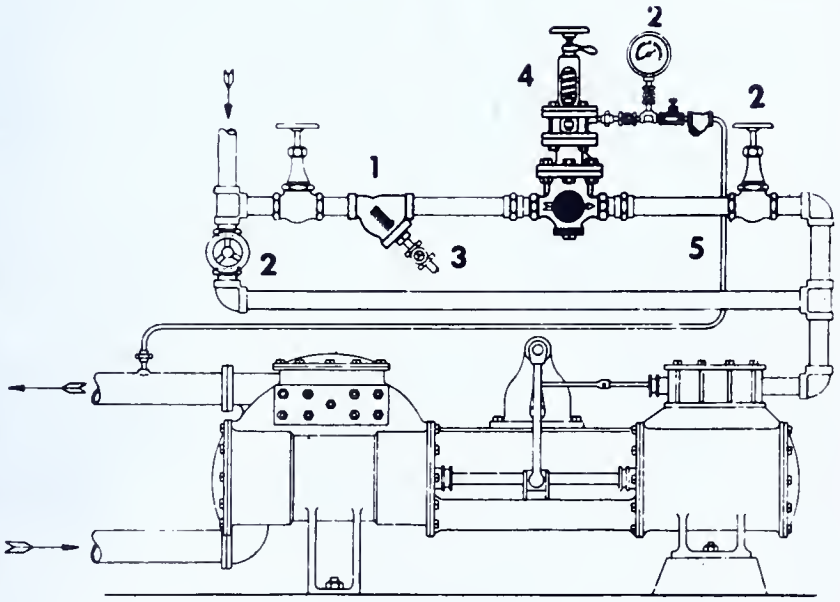


Fig. 177 — *Governor Valve Installed*

discharge pressure acts directly on the seat of the valve through a small line connected to the discharge side of the pump. If the pressure decreases, the governor valve opens and permits more steam to enter the steam end of the pump.

The action of the pump is speeded up, and the pressure rises to the regulated level. The pressure can be regulated by adjusting the small wheel on top of the governor.

A governor-valve installation is shown in Fig. 177. The explanation of the reference figures is given below:

1. Self-cleaning strainer to protect the pump governor from dirt and grit.
2. Stop valves and gauge to control setting and operation of governor.
   Note the by-pass around the governor.
3. Blow-off valve for cleaning pipe lines.
4. Governor.
5. Actuating pipe with stop-valve union, gauge-installed governor, and discharge line.

Reducing Valve

A reducing valve (Fig. 178) is used to reduce (lower) pressure in a line. The pressure allowed to pass through the valve is regulated by the small adjusting wheel on the top of the valve.

If the pressure builds up too much, the valve seat automatically closes until the pressure is lowered again. A reducing valve can be used in a steam, air, or gas system.

The explanation of the reference figures is given below:

1. Seat ring
2. Cylinder liner
3. Main valve
4. Piston
5. Top cap
6. Bottom cap
7. Control-valve seat
8. Control-valve
9. Diaphragm
10. Adjusting spring
11. Adjusting-spring case
12. Main-valve spring
13. Control-valve spring

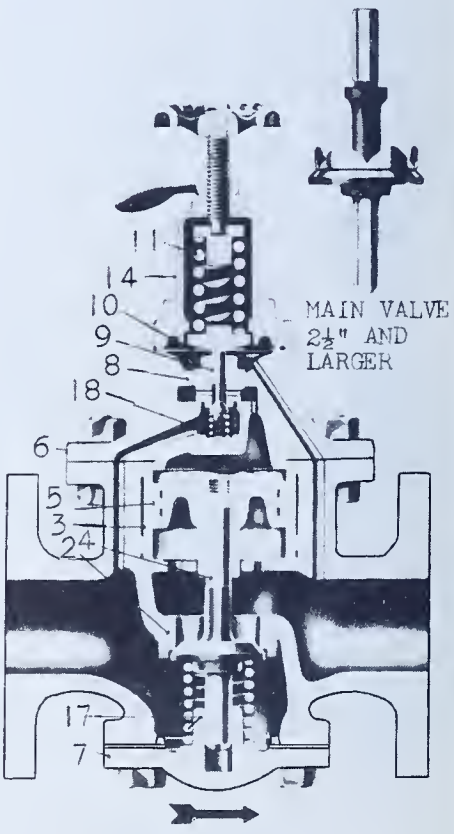


Fig. 178 — *Reducing Valve*

QUESTIONS

1. What is the purpose of a valve in a pipe line?
2. Explain the difference between a globe valve and a gate valve.
3. What is understood by the term "rising spindle" as applied to a gate valve?
4. Explain the difference between an "angle valve" and a "straight through" valve.
5. Describe a swing check valve.
6. State the difference between a swing check valve and a horizontal-lift check valve.
7. Explain how a quick-opening valve works.
8. In what type of pipe line is a swing check valve generally used?
9. Explain the construction of a needle valve.
10. Where are needle-type valves usually installed?
11. What peculiar feature does a radiator valve have that is not found in other valves?
12. Describe a butterfly valve.
13. Explain the construction and use of a relief valve.
14. Point out the advantages found in manifold valves.
15. Explain the construction and use of plug cocks.
16. Describe a typical fire valve.
17. What is another word for a Y valve?
18. What is the purpose for this type of valve?

INFORMATION SHEET 5
GASKET MATERIAL AND PIPE THREAD COMPOUND

Very rarely, in marine piping assemblies, is a metal-to-metal contact found. Flanges are separated by means of spacing material called gaskets. These gaskets are flexible enough to be pressed into any irrgularities or pits that may be on the flanges. In high-pressure systems they must be strong enough to withstand great pressures. In oil lines they must not dissolve or soak up any of the fluid. In steam lines they must be able to resist the effects of high temperatures. Several of the more commonly used types of gaskets will be discussed here.

Flexitallic Gaskets — This type of gasket may be used anywhere, but it is especially adapted for high-temperature, high-pressure systems. It is constructed of alternate spiral layers of metal and more metallic filler. The metal serves as a spring and also as a protection for the non-metallic layers. Flanges may be disassembled without harming the gasket.

Garlock Gaskets — Gasket materials in sheet form or fitted form are available in this type of material. It is a synthetic rubber preparation capable of resisting heat, corrosion, and the effects of oil. It has been used satisfactorily in high-temperature and high-pressure steam systems.

Tauril Gaskets — The material used in these gaskets is similar to the Garlock material.

Wire-inserted Asbestos Gaskets — These gaskets are used in high-temperature steam systems where there is little need for frequent disassembly.

Hydroil, Oilene, and Trunkboard Gaskets — These gaskets are used in lubricating. oil and cargo-oil piping systems. Their use is not restricted to oil line; they may be used in other low-pressure systems.

Red-Rubber Gaskets (Cloth-Inserted Rubber) — Cold-water systems are usually installed with rubber gaskets.

Pipe-thread compound, often called pipe-thread lubricant or "pipe dope" is used on all threaded assemblies. There are several kinds commonly used in marine work. Certain types of compound are more suitable for certain types of work. Pipe-thread compound should be used only on the male parts of threaded fittings. Certain types contain poisonous ingredients and should be used carefully in fresh water systems. Other types are gummy, become extremely hard, cause valves to stick, or cause other difficulties that necessitate the disassembly of the system. If the compound is applied to female fittings, most of the compound will be pushed into the pipe and the above-mentioned troubles will result. The pipe-thread compound acts as a lubricant in that it eliminates seizing of the threads. In other cases the compound acts as a sealer for small flaws in the thread and prevents leaking joints.

Expando is one of the common types of thread compound used in the pipefitting department. It is purchased in powder form and mixed in small quantities with water. It hardens in a few hours. This compound is frequently used on steam and ammonia lines. The thread is not injured when the joint is taken apart.

Key paste — This type of thread compound serves as an excellent lubricant for threads; it is also used extensively on gaskets to keep them from sticking to adjoining parts.

QUESTIONS

1. **Explain why gaskets are used between flanges.**
2. **What types of gaskets are suitable for use in main steam systems?**
3. **Give example of gaskets suitable for use in auxiliary steam lines.**
4. **What gaskets might be used in fresh-water systems?**
5. **Gaskets suitable for cold-water systems might not be suitable for use in fuel-oil piping systems. Why?**
6. **What is the purpose of using pipe-thread compound on threaded assemblies?**
7. **Is pipe-thread compound used only on pipe threads?**
8. **Why should pipe-thread compound be used only on male threads?**
9. **Explain how pipe-thread compound serves as a lubricant.**

PART V
ELEMENTARY PIPEFITTING PRACTICE

JOB SHEET NO. 1

TO DETERMINE THE LENGTH OF A PIECE OF PIPE NEEDED TO CONNECT TWO FITTINGS AT A GIVEN DISTANCE

General Information

Perhaps one of the most common jobs that confronts a marine pipefitter from day to day is figuring the length of pipe needed to connect two fittings which are a certain distance apart.

There are many different types of fittings, such as cast iron, malleable iron, steel, etc. Each type of fitting will have different over-all sizes as will the different types of pipe. A general table will not be given for this reason. The pipefitter may measure the fitting, or the measurements may be obtained from a job blueprint. The distance

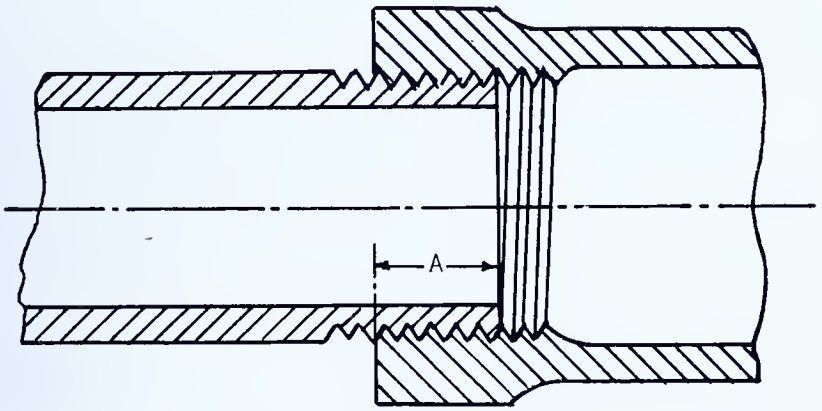


Fig. 179 — *Normal Thread Engagement*

that a piece of pipe should screw into a fitting is fairly well standardized. See Fig. 179. The distance differs according to the size of the pipe being used. The normal engagement will not vary enough in the different grades or types to affect the measurements of the pipe length. See Table No. 7.

It must be remembered that in screwed pipe, the fittings take up a certain amount of space, and the pipe will screw a certain distance into the fitting. It is important

that these distances should be taken into consideration, or the pipe will not fit. Where flanged fittings are used, the measurements are taken from face-to-face of the fittings, minus the space taken up by the gaskets. This can be easily understood as the pipe must screw into the flange until the end of the pipe is approximately flush with the face of the flange.

Table No. 7

DIMENSIONS FOR DISTANCE *A* IN FIG. 179

Pipe Size	Dimension A Inches	Pipe Size	Dimension A Inches	Pipe Size	Dimension A Inches
1/8″	1/4″	1½″	11/16″	5	1¼″
1/4″	3/8″	2″	3/4″	6	1-5/16″
3/8″	3/8″	2½″	15/16″	7	1⅜″
1/2″	1/2″	3″	1″	8	1-7/16″
3/4″	9/16″	3½″	1-1/16″	9	1½″
1″	11/16″	4″	1⅛″	10	1⅝″
1¼″	11/16″	4½″	1-3/16″	12	1¾″

The following work procedure will involve securing materials, figuring the normal thread engagement, measuring, and using hand tools.

Measuring for Pipe and Fittings

Measurements for pipe and fittings are always taken from centers somewhere on the job. When a pipe line must be run through two bulkheads aboard ship, the measurements are taken as shown in Fig. 180. The center lines are shown in the figure just as they appear on the blueprint. The completed pipe line is shown in Fig. 181 just as it will appear when the pipe and fittings are screwed together.

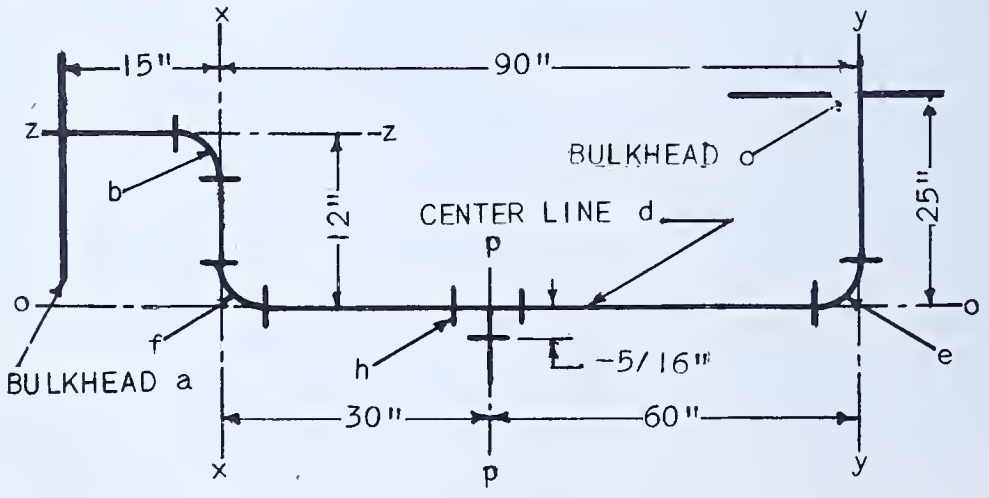


Fig. 180 — *Pipe Line Representation*

Measuring the Job

Table No. 8 shows the dimensions of various pipefittings. If the pipe line shown in Fig. 181 is made up of ¾″ pipe and fittings, the measurements are taken as follows:

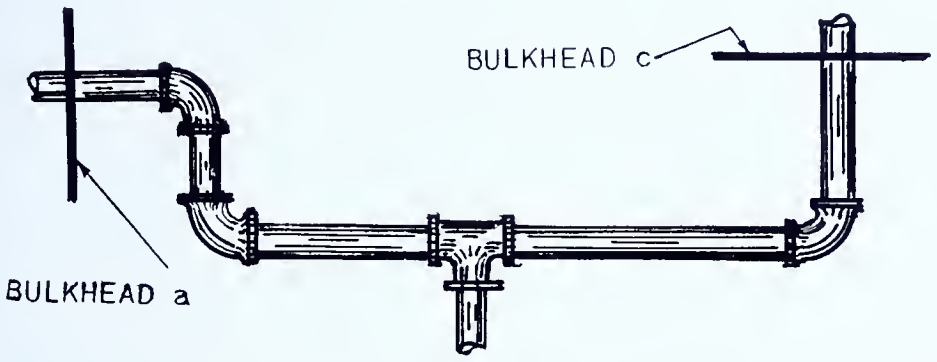


Fig. 181 — *Part of a Pipe Line Completed*

Procedure

1. Measure from bulkhead *a* to the first elbow *b* and mark the measurements on a sketch of the job.

   Make a sketch like Fig. 180 to suit every job.

2. Measure the other distances in the same manner and mark the measurements on the sketch. See Fig. 180. (The information given below is an outline of the logical procedure to be followed.)

Obtaining the Pipe Lengths

Example 1

The distance from bulkhead *a* to center line *x-x* is 15″. The distance from the face of elbow *b* to the center line *x-x* is 1 5/16″. (See Table No. 8).

The amount the pipe extends into any ¾″ fitting is ⅝″. (See Table No. 7).

The length of the pipe required to extend from bulkhead *a* into elbow *b* = (15″ — 1 5/16″) + ⅝″ = 14 5/16″.

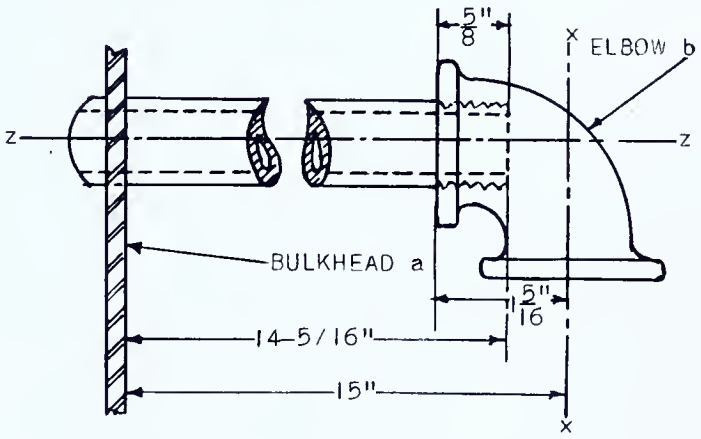


Fig. 182 — *Measuring for Pipe Length*

Study the sketch, Fig. 182, to follow the procedure for obtaining the length of the pipe required to extend from bulkhead *a* into elbow *b*.

EXAMPLE 2

The distance from center line *z-z* to center line *o-o* is 12″.

The distances from the faces of elbows *b* and *f* to the center lines *z-z* and *o-o* measure 1 5/16″ in both instances. (See Table No. 8).

1 5/16″ x 2 = 2⅝″ the combined distances from the faces of the elbows to the center lines. Both ends of the pipe must extend into the elbows ⅝″.

⅝″ x 2 = 1¼″. The length of the pipe required to extend from elbow to elbow = (12″ − 2⅝″) + 1¼″ = 10⅝″.

Study the sketch, Fig. 183, to follow the procedure for obtaining the length of the pipe required to extend from elbow *b* to elbow *f*.

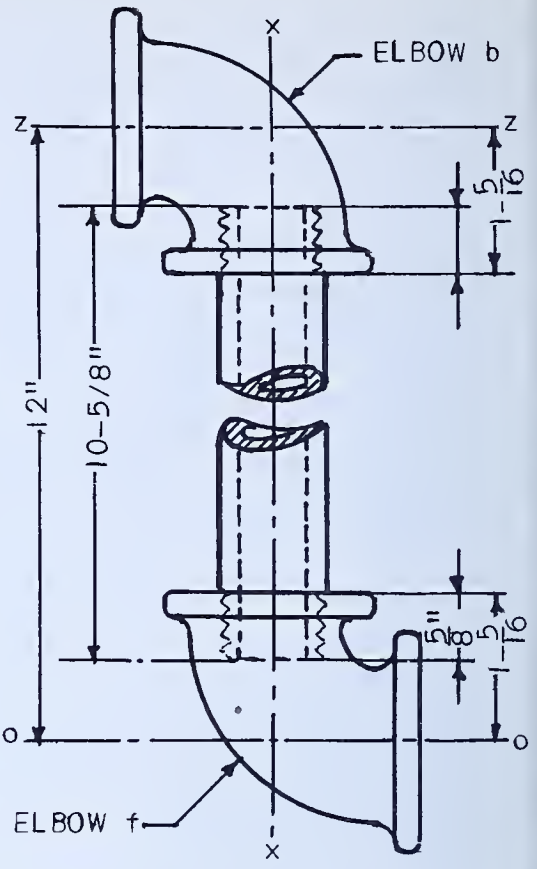


FIG. 183 — *Measuring Length of Pipe Between Elbows*

EXAMPLE 3

The distance from center line *x-x* to center line *p-p* is 30″.

The distance from the face of elbow *f* to the center line *x-x* is 1 5/16″.

1 5/16″ x 2 = 2⅝″ the combined distances from the faces of elbow *f* and tee *h* to the center lines. Both ends of the pipe must extend into the fittings ⅝″. ⅝″ x 2 = 1¼″.

The length of the pipe required to extend from elbow *f* to tee *h* = (30″ − 2⅝″) + 1¼″ = 28⅝″.

Study the sketch at the right to follow the procedure for obtaining the length of the pipe required to extend from elbow *f* to tee *h*.

Continue in the same manner to take measurements for the rest of the pipe line. Where a pipe passes through a bulkhead, measure on the other side of the bulkhead as explained in the foregoing and add the two measurements for the total length of the pipe required.

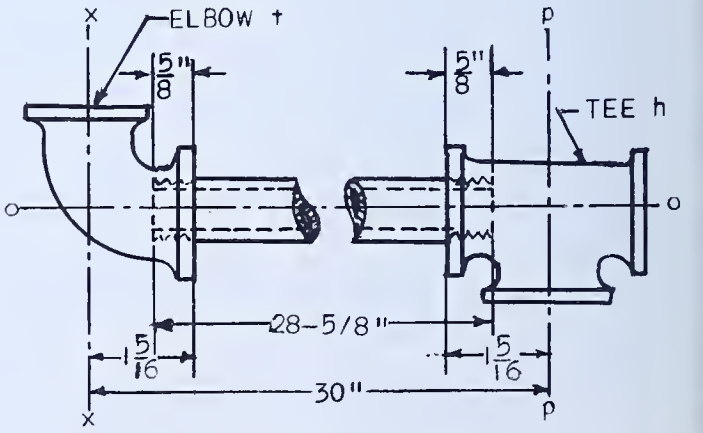


FIG. 184 — *Measuring Length of Pipe Between Elbow and Tee*

Allowing for Pipe Thread

Table No. 7 shows that the length of thread on a ¾″ pipe is ⅝″. To find the length of a ¾″ pipe that is required for the job shown in Fig. 187 it is necessary to subtract the center-to-face distance of the two ¾″ elbows from the center-to-center distance of the two elbows and then add the lengths of the threaded ends of the straight piece of pipe. Table No. 8 gives the center-to-face distance of a ¾″ elbow as 1 15/16″. For two elbows the distance is 2⅝″. The total length of the thread on both ends of the pipe is 1¼″.

Assume that the center-to-center distance of the assembly in Fig. 187 is 41 inches.

Then the length of the pipe required will be:

41 — 2⅝″ = 38⅜″ = inside face-to-face distance of the two elbows.

38⅜″ + 1¼″ = 39⅝″ = length of the straight piece of pipe required.

Assembling the Pipe Line

When the several lengths of pipe have been found and marked on the sketch, the pipefitter takes it into the shop and proceeds to cut pipe for the job.

The location of each piece of pipe may be marked on the sketch and a corresonding mark may be painted on the pipe lengths to facilitate identification at assembly.

The pipefitter is expected to measure and mark on a sketch the lengths of pipe required for the entire pipe installation. This procedure eliminates running back and forth between the ship and the pipe shop.

After the C-to-C measurements have been taken and marked on a sketch, the pipefitter obtains all the necessary fittings for the job from the storeroom. Perhaps the fittings will vary in size or weight because the available supply is furnished by different fitting manufacturers. In this case the pipefitter measures each fitting for dimensions from center-to-face and cuts the pipe accordingly.

As each piece of pipe is cut, it is screwed or welded into the correct fitting and as much of the line is assembled in the shop as possible. In some instances there remain only a few joints to be made when the pipe line is taken aboard ship.

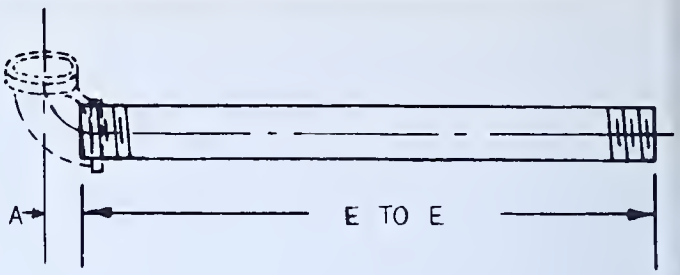
When the entire job has been made ready, the assembled pipe and fittings are taken aboard ship and installed.

Screw-Pipe Measurements — On some screw pipe the measurements may be taken in three different ways:

1. *End-to-center* — The pipe is threaded on one end, the fitting made up on that end, and the measurement taken from the center of the fitting to the end of the pipe (Fig. 185).

Fig. 185 — *End-to-Center Measurement*

2. *End-to-end*—Allowances are made for the centers of the fittings. (Fig. 186). Allowances are made on each end of pipe for the distance from center of fitting to end of pipes as at *A*, in Fig. 186.



3. *Center - to - center* — Allowance is made as in Fig. 187. In taking measurements, a pipefitter must also know the allowances made for screwed fittings. One method is to measure the approximate distance and the other is to refer to a table or chart giving the general dimensions of fittings. Table No. 8 gives the dimensions for screwed fittings.

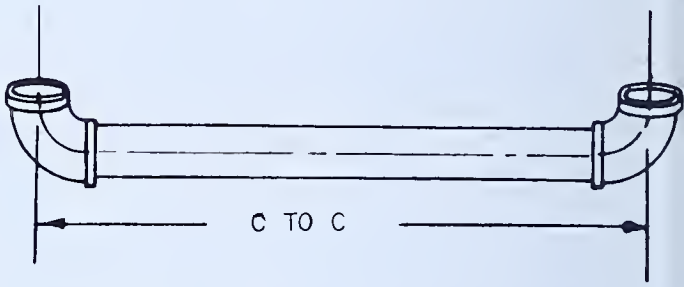


FIG. 187 — *Center-to-Center Measurement*

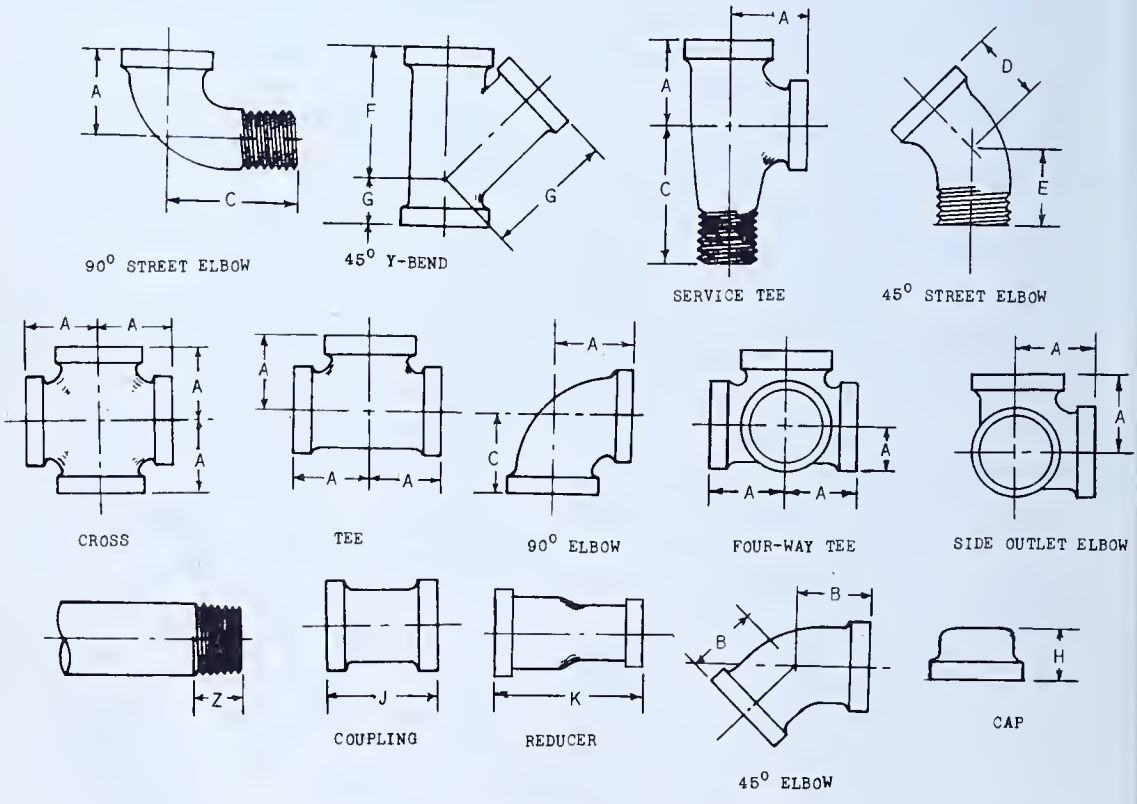


FIG. 188 — *Dimensions of Screwed Fittings*

Table No. 8

*STANDARD MALLEABLE IRON FITTINGS

Dimensions, in Inches

SIZE	A	B	C	D	E	F	G	H	J	K	Z
1/8	11/16	1/2	1	11/16	13/16			9/16	15/16		1/4
1/4	13/16	3/4	1- 3/16	5/8	15/16			5/8	1- 1/16	1	3/8
3/8	15/16	13/16	1- 7/16	11/16	1- 1/16	2- 1/8	1- 7/16	3/4	1- 3/16	1- 1/8	3/8
1/2	1- 1/8	7/8	1- 5/8	13/16	1- 3/16	2- 7/16	1-11/16	7/8	1- 5/16	1- 1/4	1/2
3/4	1- 5/16	1	1- 7/8	15/16	1- 5/16	2-13/16	2- 1/16	1- 1/16	1- 1/2	1- 7/16	9/16
1	1- 1/2	1- 1/8	2- 1/8	1- 1/16	1- 1/2	3- 3/8	2- 7/16	1- 3/16	1-11/16	1-11/16	11/16
1-1/4	1- 3/4	1- 5/16	2- 7/16	1- 1/4	1-11/16	4- 1/16	2-15/16	1- 1/4	1-15/16	2- 1/16	11/16
1-1/2	1-15/16	1- 7/16	2-11/16	1- 3/8	1- 7/8	4- 1/2	3- 5/16	1- 5/16	2- 1/8	2- 5/16	11/16
2	2- 1/4	1-11/16	3- 1/4	1-11/16	2- 1/4	5- 7/16	4	1- 7/16	2- 1/2	2-13/16	3/4
2-1/2	2-11/16	1-15/16	3-13/16	1- 7/8	2- 9/16	6- 1/4	4-11/16	1- 5/8	2- 7/8	3- 1/4	15/16
3	3- 1/8	2- 3/16	4- 1/2	2- 1/8	3	7- 1/4	5- 9/16	1- 3/4	3- 3/16	3-11/16	1
3-1/2	3- 7/16	2- 3/8	5- 1/8	2- 3/8	3- 3/8			1-15/16	3- 7/16	4	1- 1/16
4	3- 3/4	2- 5/8	5-11/16	2- 1/2	3- 3/4	8- 7/8	6-15/16	2- 1/16	3-11/16	4- 3/8	1- 1/8
5	4- 1/2	3- 1/16	6- 7/8					2- 5/16	4- 1/4	3- 7/8	1- 1/4
6	5- 1/8	3- 7/16	6					2- 9/16	4- 3/4	4- 3/8	1- 5/16

*Courtesy Crane Company

Table No. 9 gives the dimensions of flanged fittings.

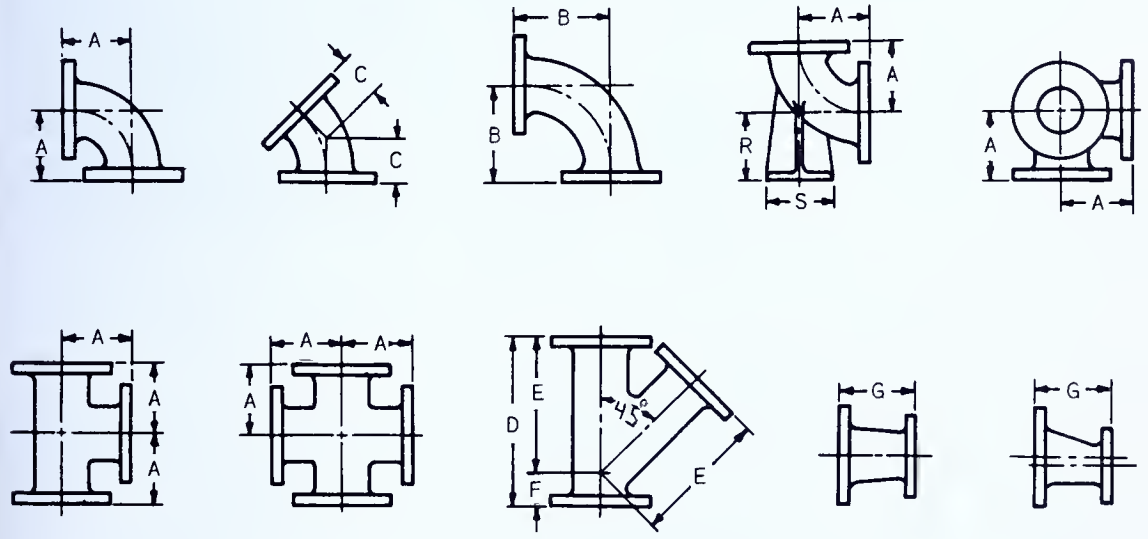


FIG. 189 — *Dimensions of Flanged Fittings*

Table No. 9

*125 POUND CAST IRON FLANGED FITTINGS

American Standard Dimensions

SIZE INCHES	A	B	C	D	E	F	G	R	S	FLANGE DIAM.	FLANGE THICKNESS
1-1/2	4	6	2-1/4							5	9/16
2	4-1/2	6-1/2	2-1/2	10-1/2	6	2-1/2				6	5/6
2-1/2	5	7	3	12	9-1/2	2-1/2	5-1/2			7	11/16
3	5-1/2	7-3/4	3	13	10	3	6			7-1/2	3/4
3-1/2	6	6-1/2	3-1/2				6-1/2			6-1/2	13/16
4	6-1/2	9	4	15	12	3	7	5-1/2	6	9	15/16
5	7-1/2	10-1/4	4-1/2	17	13-1/2	3-1/2	6	6-1/4	7	10	15/16
6	6	11-1/2	5	18	14-1/2	3-1/2	9	7	7	11	1
8	9	14	5-1/2	22	17-1/2	4-1/2	11	8-3/6	9	13-1/2	1 - 1/8
10	11	16-1/2	6-1/2	25-1/2	20-1/2	5	12	9-3/4	9	16	1 - 3/16
12	12	19	7-1/2	30	24-1/2	5-1/2	14	11-1/4	11	19	1 - 1/4

*Courtesy Walworth Company

Measurement of bends and offsets, as well as of straight pipe, must be made. In fact, the majority of the pipefitter's measurements will be on bends and offsets.

MEASURING A 90° BEND — Place the bend on the floor or bench, and lay a straightedge along the center of the straight part of the pipe. The distance from the face of the flange to the edge of the straightedge on the pipe is the measurement of the bend as shown in Fig. 190.

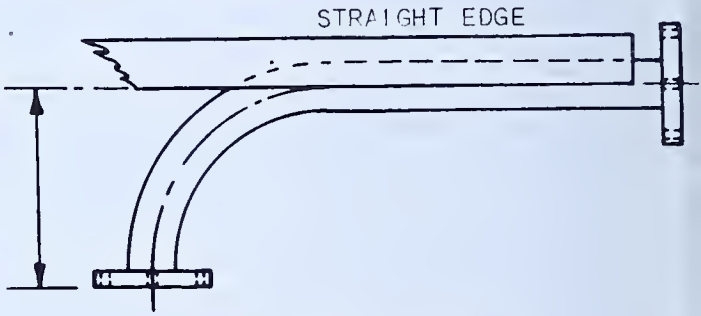


FIG. 190 — *A 90° Bend*

MEASURING AN OFFSET — Place the offset on a bench or floor, and put a straightedge on the pipe. Measure the distance from the edge of the straightedge to the side of the pipe as shown in Fig. 191.

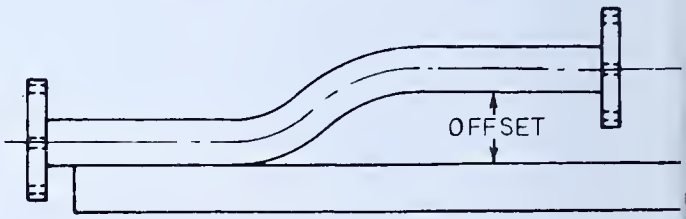


FIG. 191 — *An Offset*

FLANGED PIPING—On flanged piping, the measurements are always taken from face-to-face with allowances made for gaskets and welding.

1. Flat-faced flanges for low-pressure joints. Fig. 192.

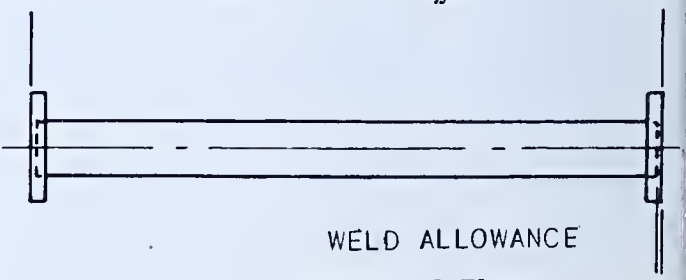


FIG. 192 — *Flat-Faced Flange*

2. Raised-face flange for high-pressure joints. Fig. 193.

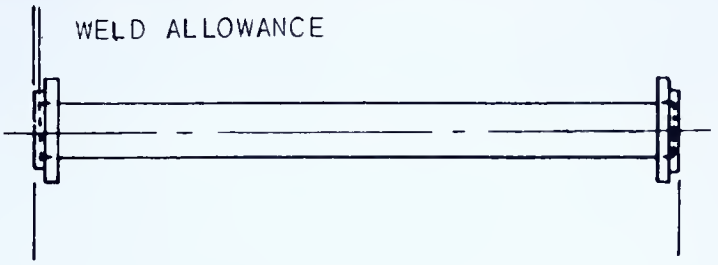


FIG. 193 — *Raised-Face Flange*

In measuring a face-to-face distance of an offset, hold the straightedge on the face of the flange and measure to the face of flange on other end of pipe. Fig. 194.

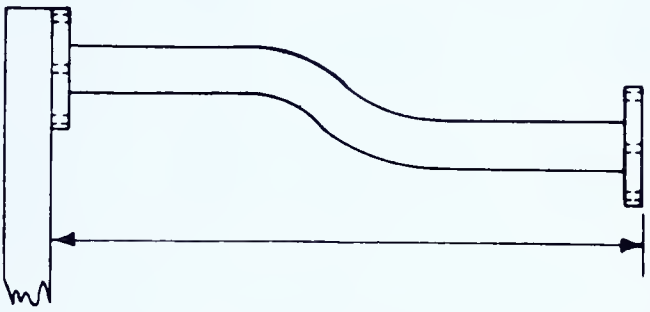


FIG. 194 — *Flanged Offset*

The procedure for measuring for the lengths of pipe to make up a pipe line composed of screwed fitting and pipe may be summarized as follows:

Observe the following rules when measuring for pipe-line installations.

1. Check the blueprint carefully for the correct location of the pipe line.
2. Make a sketch and dimension it to show the centers of the pipe line and the faces of the fittings.
3. Obtain the necessary fittings from stores.
4. Check the center-to-face distances of each fitting, and cut pipe to suit.
5. Assemble pipe and fittings as soon as each length of pipe is cut.
6. Check the pipe centers as each length is screwed into the assembly.
7. Make up in the shop as much of the pipe line as possible.
8. Check for correct center-to-center distance.
9. If the work is approved, take the pipe assemblies to the ship for final installation.

PROBLEM: Figure the length of a piece of one-inch pipe necessary to connect two fittings at a given distance apart.

The following procedure may be used to find any length of any size of pipe line. The length of an entire piping system must be determined from fitting to fitting. On board a ship, the pipe runs may be very long or short, and may be very crooked or in a straight line. Many fittings are used.

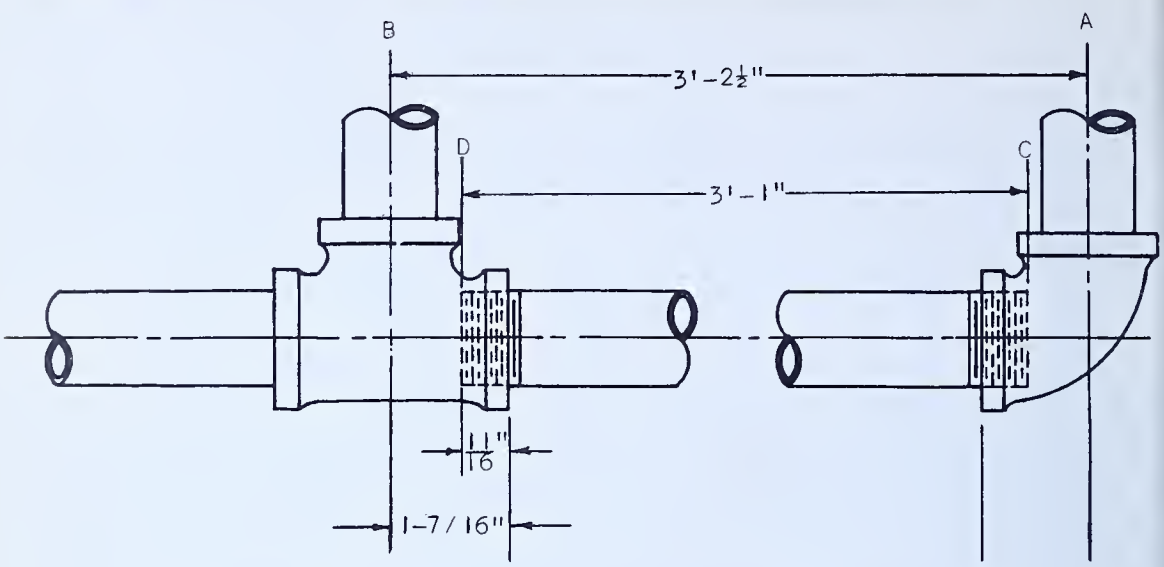


FIG. 195 — *Pipe Installed After Computing Dimensions*

TOOLS AND EQUIPMENT

1. Stillson wrenches
2. Hack saw
3. Pipe dies and stock
4. Rule

MATERIALS

1. Fittings
2. Lengths of one-inch pipe
3. Soapstone
4. Pencil and paper
5. Oil
6. Thread dope

PROCEDURE

1. With a rule, measure the distance between the two desired centers, *A* and *B*, Fig. 195. The distance is 3′ 2½″.
2. Obtain a one-inch 90° ell and a one-inch tee.

   Instructor may assign other fittings.
3. Refer to the table in General Information for the normal thread engagement for standard 1″ pipe.

   Normal thread engagement for a 1″ pipe is 11/16″.
4. Measure 11/16″ from the end of each fitting.
5. Mark a line *C* on the 90° elbow, and a line *D* on the tee, using soapstone or chalk.
6. Measure the ell fitting from point *C* to the center line *A*. This will be ¾″.
7. Measure the tee fitting from point *D* to center line *B*.

   This will be ¾″. The distance from the end to center of the tee, and the distance from the end to the center of the 90° ell is the same. This does not hold true of a 45° ell.

Steps 6 and 7 are not necessary if a table of screwed fittings is available. Refer to Page 107 for a table giving the face to center measurements of fittings. Table 8 gives the center-to-the-end measurement as 1 7/16″ for a one-inch pipe size. Subtract the normal thread engagement, 11/16″, from 1 7/16″. The remainder, ¾″, is the distance the ends of the pipe will be from the center line *B*.

8. Add the distances *A* to *C*, and *B* to *D*.
   ¾″ + ¾″ = 1½″.
9. Subtract 1½″ from 3′ 2½″. 3′ 2½″ − 1½″ = 3′ 1″.
   This is the distance between lines *C* and *D* and the length of the piece of pipe *F* to be installed between the two fixed points.
   For additional pipefitting practice, the instructor may require pipe to be cut, threaded, and installed between fixed points after the worker has determined the length of pipe needed. Check upon completion for correctness of measurements.
10. Select a piece of 1″ pipe stock and mark to desired length with soapstone or chalk.
11. Place pipe in a vise, and cut off with a hacksaw (or pipecutter).
12. Thread the pipe with a 1″ die and stock.
    Use oil while cutting threads.
13. Apply thread dope to threads.
14. Install pipe in fittings.
    Tighten with wrench, and check ell and tee to see that the run of each is on the same level and in the same direction.
15. Install desired fittings on given lines.

QUESTIONS

1. Explain the difference (if any) between the method of measuring flanged fittings and the method of measuring screwed fittings.

2. Figure the following measurements:

   a. The length of $\frac{3}{8}''$ pipe necessary to connect a $\frac{3}{8}''$, 90° ell and a 45° ell if the distance between the centers is 4′ 6″.

   b. The length of $1\frac{1}{2}''$ pipe necessary to connect a $1\frac{1}{2}''$ ell and a $1\frac{1}{2}''$ tee if the distance between centers is 2′ 6″.

   c. The length of 2″ pipe necessary to connect a 2″ tee and a 2″, 90° ell if the distance between centers is 5′ $2\frac{3}{8}''$.

   d. The length of 3″ pipe necessary to connect a 3″ tee and a 3″, 45° ell if the distance between centers is 3′ $11\frac{1}{4}''$.

3. Does the distance a piece of pipe will screw into a fitting vary to a considerable extent? What condition causes the variation?

4. Explain why the length of pipe sections, making up a piping system, must be determined from fitting to fitting.

5. How is the length of pipe measured that has flanged connections?

6. Do all fittings have the same over-all dimensions?

JOB SHEET NO. 2
TO CUT, REAM AND THREAD A PIECE OF PIPE

General Information

Pipe cutting is a job that is worthy of extreme care and skill. Pipe that is cut correctly can be threaded accurately whether cut by a hand cutter, hack saw, or power machine. When a hand cutter is used the first cut by the cutters should be only a slight bite to insure that the starting channel will be square with the pipe before a deep bite is taken. Pipe that is not cut off square is difficult to thread accurately, and a leaky joint is usually the result. When one or more of the cutter wheels are dull, so much physical pressure on the pipe cutter will be necessary in order to get a starting channel that even a three-wheel cutter is likely to get "cocked" and produce a crooked cut or damage the pipe. Sharp cutters are essential for square-end cuts.

Burrs, ragged and sharp edges of an unreamed end of pipe, catch and accumulate sediment and eventually retard the flow of the liquid. Pieces of metal from the burr may be loosened by corrosion or pressure, lodge in the valve seats, and damage them. Pipe ends may be reamed with any one of various types of pipe reamer. The shoulder of upset metal on the outside of the pipe should be removed by filing, to allow the pipe to enter the threading tool properly.

There are many different types of hand pipe-threading tools, a few of which have been mentioned in Part III.

Some of the causes of rough, chewed threads cut by machine and by hand are: dull dies, improper lubrication, out-of-round die (caused by chips or dirt), broken

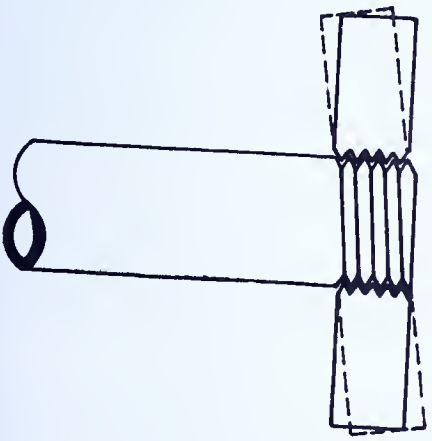


Fig. 196 — *Dies Become Tilted When Thumb Screws Are Not Securely Tightened*

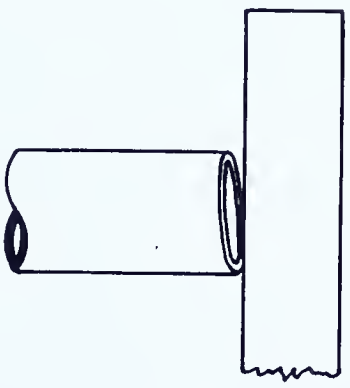


Fig. 197 — *A Crooked Pipe End*

tooth on die. A broken tooth should be ground off or the entire die should be replaced. Worn pipe tools will cause an unnecessary waste of time, labor and materials.

When the circumference of the threads cut on a pipe is wavy and cut out of true instead of forming a perfect circle, it produces so-called wavy (drunken) threads. A good leakproof connection cannot be made with wavy threads on the pipe. One way to overcome this condition is to center the die when putting it on the pipe, tighten the thumb screws with a wrench, and make sure the thumb screws stay tight. Fig. 196 shows dies that are tilted. Crooked (drunken) threads often result when pipe ends are not cut off square. See Fig. 197. If a pipe has not been cut off square, certain dies will engage the pipe and others will not as shown in Fig. 198. This causes the die to start diagonally and cut crooked threads. When one or more of the dies are doing most of the work, chip sizes and depth of threads cut will not be uniform. Keep die slots clear of chips.

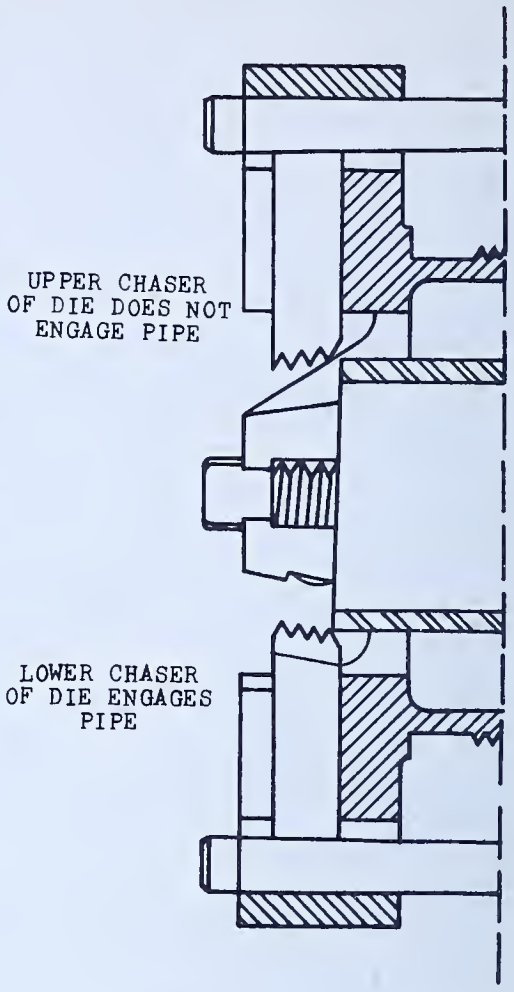


FIG. 198 — *"Drunken" Thread Caused by Angular Cut on End of Pipe*

In machine threading, wavy threads usually come from worn die slots which allow the dies to tilt. Tilting dies increase the clearance, and increased clearance causes the loss of the necessary steadying effect. See Fig. 199. A loose die should prompt cautious use. Loose dies are the cause of leaky joints as they will cut a wavy thread on the pipe which will not mesh properly with the accurately cut threads on the fitting. A leak-proof joint is possible only with clean-cut threads on the pipe and clean-cut threads on the fitting.

Another cause of leaky joints is chewed thread which may be traced to dies that are out of line. Clips (or dirt) in the bottom of the die slot keep the die from going to the bottom of the slot, and the failure of the die to seat properly causes the cutting edges on one or more dies to be thrown out of line with the cutting edges of the other dies. Incorrect grinding of the lip angle on dies results in the crumbling of chips

and roughly chewed threads. Fig. 200, *A*. Properly ground lip angles on dies result in spiral chips, the sign of the correct cutting action which produces strong, clean threads. Fig. 200, *B*.

Important things to remember in pipe threading:

1. Inspect die slots to make sure that they are clear of all dirt, gummy oil, and chips.
2. Check the cutting edges on dies and make sure that lip angles are accurately ground. Excessive lip angles on die bits are the cause of many threading troubles.
3. Be sure that pipe ends are cut off square before starting to thread.
4. Don't use dull pipe cutter wheels if you would avoid crooked cuts, excessive upset metal, or internal burrs on the pipe end.
5. Don't insert new or reground dies in a worn stock or die head and expect good results.
6. Use plenty of good cutting oil. The better the quality of the oil, the better the threads will cut and the longer the dies will do good work.
7. Don't try to economize by using dies after it is obvious that they cannot cut precision threads.
8. Be sure the die is properly centered on pipe.
9. Make it a rule to tighten thumb screws with a wrench instead of with thumb and finger.

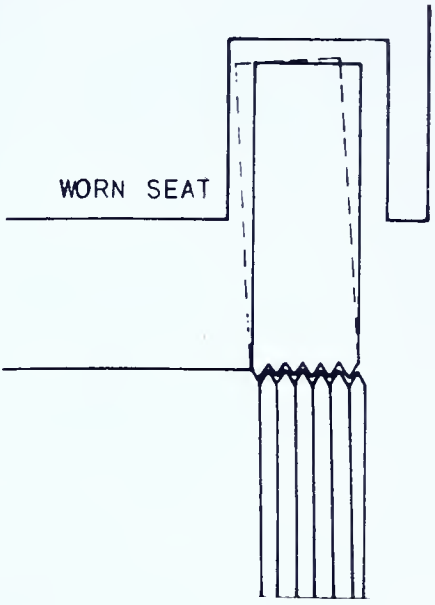
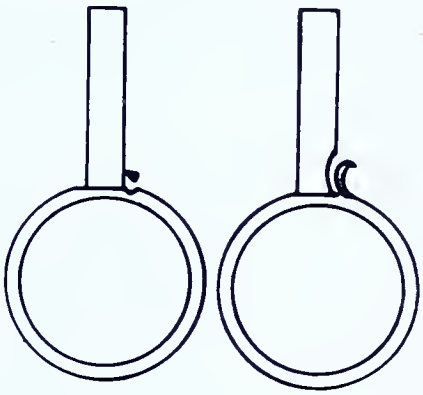


FIG. 199 — *Worn Chaser Slots*



Incorrect Lip Angle *Correct Lip Angle*

FIG. 200

10. Use the proper size of die for each different size of pipe being threaded.
11. Grinding away the lip on a die in order to fix a broken tooth ruins the whole die. Grind the broken tooth away clear down into the root.
12. Instead of using a die head with a worn-out cam, get a new die head.
13. Pipe cutters with a sprung frame will cut a "crooked track". Check up on these tools frequently.
14. When replacing dies in die stock or die head, put them back in accordance with the numbered markings on the stock or die head. If they are not marked, the order of their insertion should be clockwise.

15. Use triangular stone to take "wire edge" off new dies before using them.

16. To obtain uniformly good results, try to have threading and pipe-cutting tools (used on a particular job) about the same age and in about the same condition. Trouble often occurs when old tools are used with new tools on the same job.

PROBLEM: Cut, ream, and hand-thread a piece of 1½" standard pipe.

TOOLS AND EQUIPMENT

1. Pipe vise
2. Ratchet die
3. Pipe cutter
4. Pipe reamer
5. Hammer

MATERIALS

1. Cutting oil
2. Length of 1½" standard pipe

PROCEDURE

1. Select a piece of 1½" black pipe.

2. Place the pipe in a vise.

   Allow sufficient extra pipe to stick through the vise so that the cutter can be rotated around the pipe without striking the table or bench to which the vise is fastened.

3. Tighten the vise enough to keep the pipe from turning, but not tight enough to pinch or flatten the pipe.

4. Obtain pipe cutter.

5. Place pipe cutter on pipe; hold the handle in the right hand and the cutting end in the left hand.

6. Feed the tool firmly up to the mark where the pipe is to be cut off.

7. Screw the handle clockwise with the right hand until the cutting wheel marks the pipe clearly.

8. Rotate the cutter around the pipe so that the cutting wheel shows a true square cut around the pipe at the cut-off mark.

9. Continue to rotate the cutter, at the same time turning the cutting tool into the pipe lightly on each rotation until the pipe has been cut off.

   Support the piece being cut off so that it will not fall on the feet.

10. Remove the cutter and return it to its proper place.

11. Obtain a pipe reamer.

12. Place the point of the ratchet reamer on the inside of the end of the pipe.

13. With the left hand, hold the knob of the reamer firmly against the pipe so as to give pressure to the cutting edges of the reamer.

14. Operate the reamer by moving the handle up and down several times through an arc of about 45° until all the burrs are removed from the inside edge of the pipe.
15. Remove the pipe reamer and put it in its proper place.
16. Secure a 1½″ die and stock.
17. Grasp the handle in one hand and the head or die in the other hand.
18. Place the die on the end of the pipe.
19. Exert pressure with the hand holding the head end on the pipe and work the handle with the other hand until the die begins to cut.

    Pressure is not necessary after the dies start cutting. Be sure to use sufficient cutting oil on the dies when they are cutting.
20. Operate the handle up and down, using both hands.
21. Continue to cut threads until the required amounts are cut.
22. Reverse the ratchet by turning the ratchet-control pin halfway around.
23. Work the handle in the same manner used for cutting until the die is backed off the pipe.
24. Remove all cuttings from the threads.

    A tap on the pipe will jar the shavings loose.

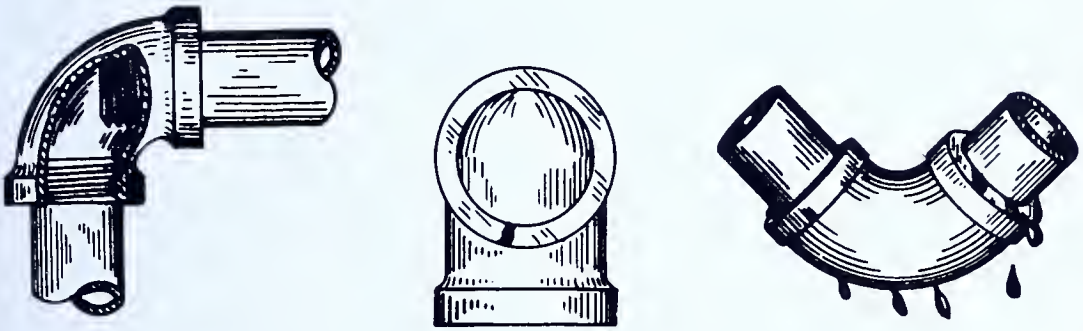
QUESTIONS

1. What is the chief difference between American Standard Screw Threads and Pipe Threads?
2. Explain the correct procedure for placing a piece of pipe in a pipe vise.
3. What is the basic difference in procedure between threading a piece of small pipe and a piece of large pipe?
4. Why should the shavings be brushed or tapped off the pipe?
5. Explain the proper procedure to start the die on the pipe.
6. Explain why only enough pipe is placed through the face of the vise to accommodate the threads to be cut.
7. How long should the threads be cut?
8. Name (trade name, etc.) and explain the differences between the different types of stocks and dies.
9. Explain why a ratchet pipe reamer is used.
10. Name several methods of cutting pipe.
11. Explain the importance of using sufficient cutting oil.
12. Explain the damage that might be caused by leaving a burred or ragged edge in the pipe.
13. Explain what happens to a pipe that has not been cut off square.
14. What are the advantages of using a ratchet die?

JOB SHEET NO. 3
TO INSTALL FITTINGS

General Information

The idea that leaky joints can be made leakproof by screwing the pipe into a fitting so far that the threaded portion of the pipe cannot be seen usually results in a damaged fitting. See Fig. 201, *A*. Trying to make a leakproof connection by physical strength



A — Threads Shouldered Against the Ell Wall

B — Cracked Bead

C — A Leaky Joint

Fig. 201

alone exerts excessive leverage on the pipe and on the fitting. When the fitting is tightened excessively, the pipe sometimes shoulders against the inside wall of the fitting and causes a leaky joint. Screwing a pipe into a fitting so far that the unthreaded portion of the pipe is immediately adjacent to the threaded section, enters and expands the fittings, very often cracks the bead as shown in Fig. 201, *B*. The result is invariably a leaky joint (Fig. 201, *C*).

Applying a wrench to the outside shoulder of a pipe fitting when installing it on a pipe line is done very frequently and unthinkingly. Such procedure sometimes results in damage to the fitting. Apply the wrench to the inside shoulder of the fitting. See Fig. 203. When such an arrangement is impossible, screw a nipple into the open end of the fitting before applying the wrench so as to prevent straining the body of the fitting or making the opening out-of-round. See Fig. 204.

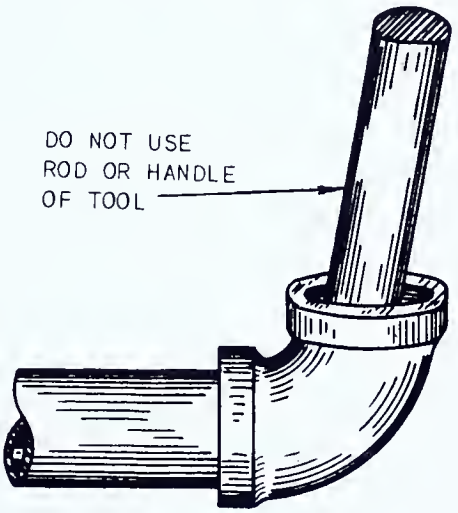


Fig. 202 — *Tightening Fitting with a Rod*

A good rule to follow in making up a joint involving a street ell is to screw the ell in first.

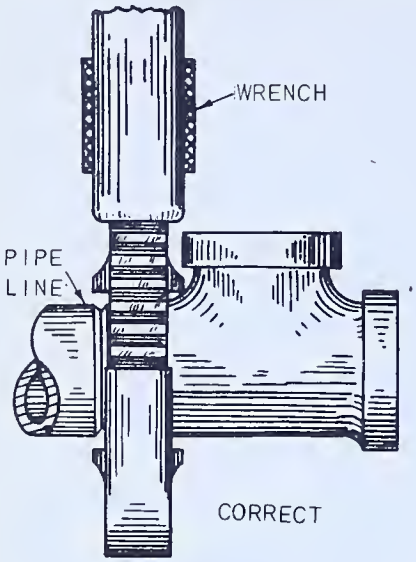


FIG. 203 — *Applying a Wrench Correctly*

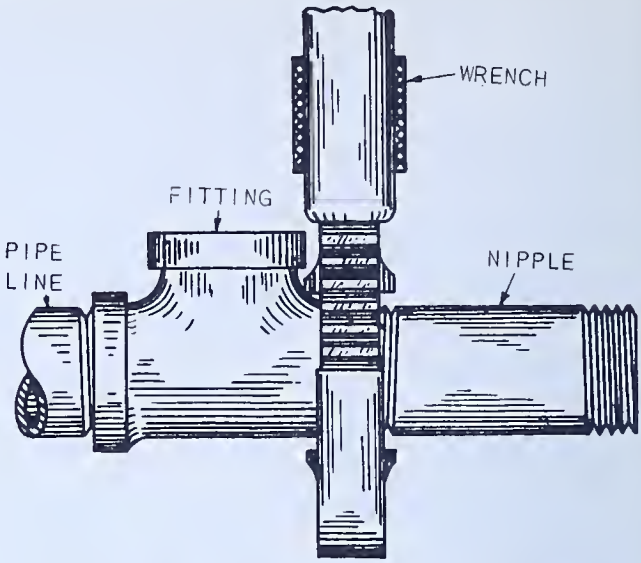


FIG. 204 — *Using a Nipple to Prevent Damage to the Fitting*

When a wrench slips and grabs the exposed threads on the street ell, damaged threads may involve costly pipe replacement as well as loss of time and labor.

Even if two pipe lines joined together by a union are in perfect alignment, a leaky joint may result. Such a condition may be caused by a bit of careless wrench work that was unnoticed and uncorrected. The practice of using one wrench to tighten the "hex" of a union without applying another wrench to keep joints on either end of the union from turning and working loose can result in a leaky joint. The remedy is the use of a second wrench. See Fig. 205.

A pipefitter who uses his pipe wrench with proper care and skill can protect himself from delays and extra exertion in his business of making pipe connections. When excessive leverage is obtained by slipping a length of pipe over the handle of the wrench, the pipe is often screwed so far into the fitting that the end shoulders against the inside wall of the fittings, or the bead on the fitting is expanded and sometimes cracked. Something usually gives way; it may be the fitting, the pipeline unit that is being assembled, or a

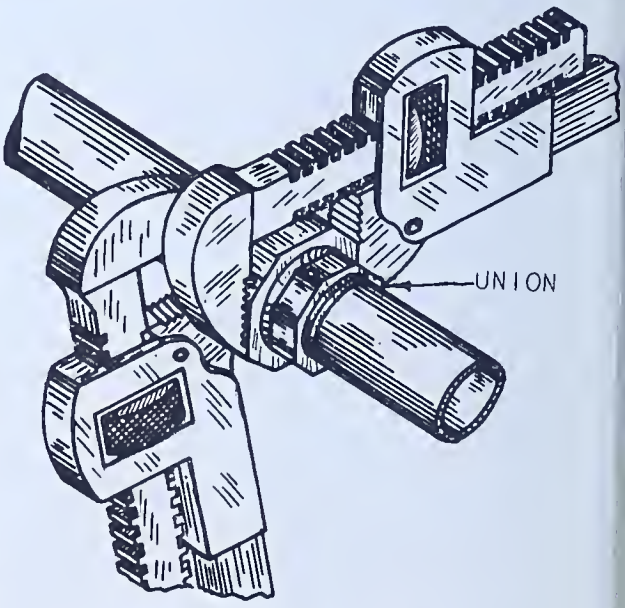


FIG. 205 — *Using Two Wrenches to Make a Tight Joint*

FIG. 206 — *Result of Excessive Leverage on the Wrench Handle*

part of the wrench. See Fig. 206. Use the correct size of wrench for the job. Fig. 207, *A* and *B*, shows the incorrect positions for a pipe wrench on a piece of pipe. A wrench placed properly on the pipe protects the wrench, the pipe, and the pipefitter.

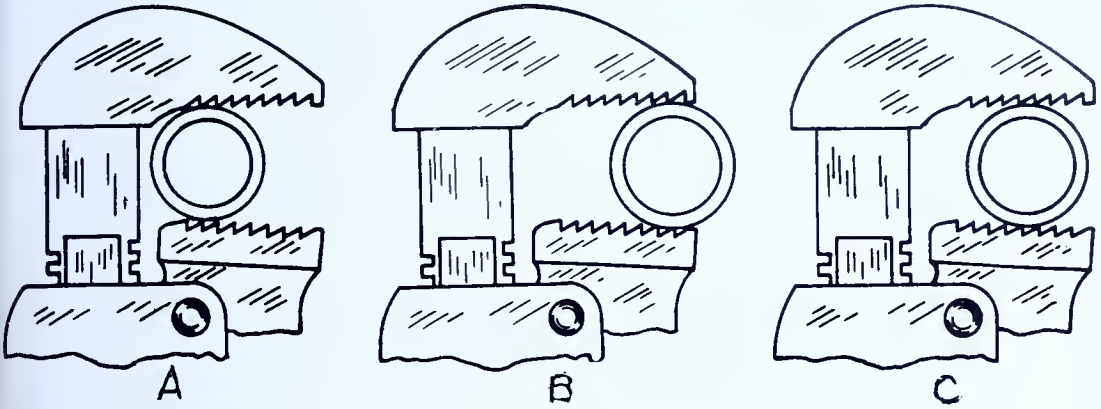


FIG. 207 — *Correct and Incorrect Use of Pipe Wrench*

The correct position is shown in Fig. 207, *C*. Table No. 10 gives the correct wrench size to use on standard sizes of pipe.

Table No. 10

APPROXIMATE SIZE OF WRENCH TO BE USED ON DIFFERENT SIZES OF PIPE:	
6" OR 8" WRENCH	USED ON 1/4 INCH PIPE
10" WRENCH	USED ON 3/8 AND 1/2 INCH PIPE
18" WRENCH	USED ON 3/4 AND 1 INCH PIPE
24" WRENCH	USED ON 1-1/2 AND 2 INCH PIPE
36" WRENCH	USED ON 3 INCH PIPE
48" WRENCH	USED ON 4 INCH PIPE

QUESTIONS

1. Name the wrench which should be used to install pipe fittings.
2. State two causes of leaky joints.
3. Explain the reasons for not using a tool handle or a piece of rod to tighten an ell.
4. What precautions should be taken to prevent leaks when a tee or a coupling is being installed on a pipe line?
5. Explain the correct method to prevent a leaky joint when a union is being installed.
6. What happens when a wrench handle is subjected to excessive leverage caused by placing a piece of pipe over the wrench handle?
7. What is the correct position of the pipe-wrench jaws when they are applied to a pipe-turning job?
8. What size of wrench should be used for screwing in a ½″ pipe?
9. State the correct size of wrench to use when installing a 4″ pipe.

JOB SHEET NO. 4
TO INSTALL A FITTING IN A FIXED PIPE LINE

General Information

The marine pipefitter is sometimes called upon to connect a fitting to a main line where no opening has been left in the line for a fitting. With these conditions in mind, it is better in many cases to cut and thread the main line into place than to remove an entire section in order to install the fitting. To perform this job, a pipefitter must cut out a section of the main line with a hack saw, thread the pipe with a ratchet die, and fill in with a tee nipple and a union. It is first necessary, however, for the pipefitter to know where the branch line is to lead off, what size the fittings are to be, and how much pipe to remove from the main line for the insertion of the branch lines. A chart showing the normal thread engagement for screwed joints may be found in Table No. 7.

Problem

Cut, Thread, and Insert a Fitting in a Fixed Pipe Line.

Tools and Equipment

1. Hack saw
2. 1″ ratchet wrench die
3. Stillson wrench
4. Rule

Materials

1. Cutting oil
2. 1″ tee
3. 1″ union
4. 1″ x 5″ nipple
5. Thread dope
6. Pencil, chalk, or soapstone

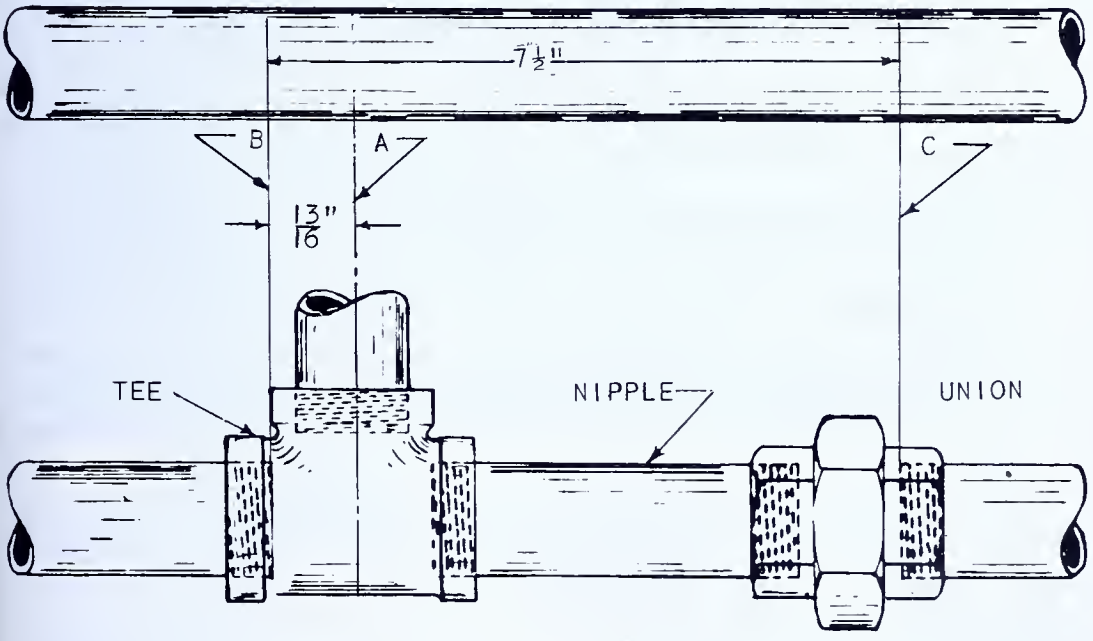


Fig. 208 — *A One-inch Main Line*

PROCEDURE

1. Determine the position where the branch line is to lead off the main line.
2. Mark this place with a small line on the main line. See *A* in Fig. 208.
3. Figure the amount of space one-half of a 1″ tee will take.
   The tee may be measured with a rule. One-half of a 1″ tee = 1½″.
4. Look up the normal engagement for screwed fittings in the table of Job Sheet No. 2.
   In this case, the normal engagement for a 1″ pipe will be 11/16″.
5. Subtract the normal engagement 11/16″ from 1½″.
   1½″ − 11/16″ = 13/16″ or the amount one-half of the fitting will take.
6. Measure 13/16″ from the point *A* in Fig. 208 and mark it as point *B*.
7. Figure the amount of space needed for the tee, union, and nipple if the tee is 3″ long, the nipple 5″ long, and the union 2⅜″ long.
   3″ + 5″ + 2⅜″, = 10⅜″, the total length of the fittings.
8. Subtract from 10⅜″ the normal thread engagement for the four screw joints.
   The normal thread engagement for 1″ pipe is 11/16″.
   11/16″ x 4 = 2¾″. 10⅜″ − 2¾″ = 7⅝″.
   7⅝″ = the space needed for the tee, nipple, and union.
9. Measure 7⅝″ from point *B* with a rule and make a mark *C*.
10. Obtain a hack saw, and cut the pipe at points *B* and *C*.
    Use correct hack sawing procedure. Cut the pipe at right angles.
11. Remove the section cut out with the hack saw.
12. Obtain a 1″ ratchet die and stock.
13. Thread the ends of the pipe at points *B* and *C*.

    CAUTION: The operator must be sure to keep the die well oiled while he is cutting threads.

    Hold the die in one hand and the handle in the other. Place the die on the pipe and work the handle until the die begins to cut. Pressure is not necessary after the die once begins to cut. Refer to Job Sheet No. 2 for correct pipe-threading procedure.
14. Remove the pipe die and knock the chips off the ends of the pipe.
15. Apply thread dope to the threaded end of the pipe.
16. Install the tee at point *B*.

17. Pull the tee tight with a Stillson wrench.

    Be sure that the outlet of the tee is left in the correct position. See the tee in Fig. 208.

18. Screw (by hand) one side of the union onto the nipple.

19. Screw the nipple into the tee.

20. Pull the nipple and the union tight, using a Stillson wrench. See the nipple in Fig. 208.

21. Pull the main line to one side and install the other half of the union on the pipe at point *C*.

22. Pull tight with a Stillson wrench.

23. Place the two halves of the union together.

24. Tighten the union with a wrench.

QUESTIONS

1. **Explain why it is necessary to know the normal thread engagement for screwed joints.**
2. **Why is it essential to determine the exact point where the branch line is to lead off?**
3. **Explain what is meant by "leaving the tee outlet in the correct position".**
4. **Why should it be necessary to spring part of the line to one side?**
5. **Figure how much pipe should be removed from a 1½″ line in order to install a tee and a 5″ nipple.**
6. **Figure how much pipe should be removed from a 2″ line in order to install a tee and a 6″ nipple.**
7. **Is it always advisable to cut and thread the main line to install a tee? What else may be done?**
8. **Explain the proper method of installing a nipple and half of the union.**

JOB SHEET NO. 5
TO BY-PASS A METER

General Information

The reason a by-pass is installed in a piping system is to make it possible to repair or replace a unit (a meter, reducing valve, constant-pressure valve, etc.) without interrupting the flow of pressure to other units that might be on the line. A by-pass is usually placed in any position relative to the supply line but it is generally placed with all the valve stems in a vertical position. Fig. 209 shows a method of by-passing a meter.

When the meter is in use, valves C and C_1 are open, and valve H is closed. To remove or repair the meter, valves C and C_1 are closed, and valve H is opened.

Problem: By-pass a meter, using one-inch pipe.

Tools and Equipment

1. Two Stillson wrenches
2. Rule
3. Pipe die and stock

Materials

1. One 1″ liquid meter
2. Three 1″ globe valves
3. Two 1″ tees
4. Three 1″ unions
5. Two 1″ ells
6. Seven 1″ x 3″ nipples
7. Thread dope
8. Lengths of 1″ pipe

Procedure

Note: Apply thread dope to all pipe threads before assembling.

1. Screw one 1″ tee fitting B into supply pipe A with the opening straight through (on the run).
2. Tighten tee with wrench, leaving the side outlet facing down.
3. Screw one nipple in the tee B hand-tight.
4. Start one valve C on the nipple so that the pressure will enter under the valve seat.
5. Tighten valve with a wrench on the valve end nearest the nipple.
6. Align the valve stem, pointing up, when the valve is tight.
7. Insert another nipple in valve C.
8. Start the male half of the union D on the end of the nipple.
9. Tighten union and nipple.
10. Start another nipple in the meter.

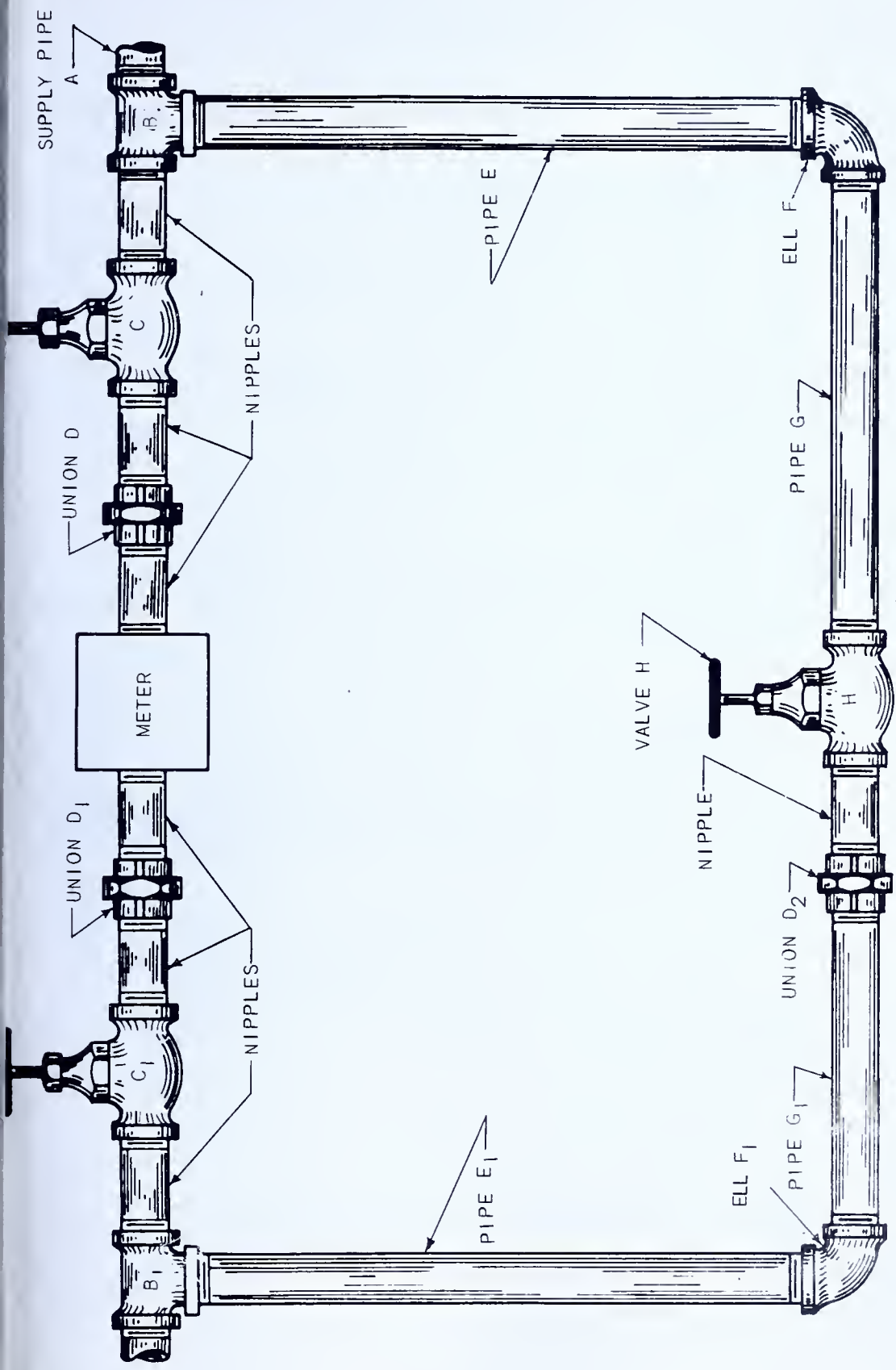


FIG. 209.— *By-Passing a Meter with 1″ Pipe and Fittings*

11. Start female half of union D on other end of nipple.
12. Tighten female half of union and the nipple.
13. Set the meter in place, and connect the union D.
14. Screw one 1″ tee fitting B_1, on the other end of pipe A, with the opening straight through.
15. Pull tee tight, with the outlet facing down.
16. Line up the run of the tee B_1, with pipe A.
17. Start a 1″ x 3″ nipple in the opening of tee B_1, facing the meter.
18. Screw a valve C_1, on the end of the nipple.
19. Pull valve tight, making sure the valve stem is in a vertical position.
20. Start another nipple in valve C_1.
21. Start male half of union D_1 on the other end of the nipple.
22. Pull union and nipple tight.
23. Disconnect the meter.
24. Start one end of the nipple in the meter with the female half of the union on the other end, and pull it tight.
25. Spring pipes apart.
26. Place the meter in position.
27. Anchor the meter by pulling both union nuts tight.
28. From the center of the tee B on the supply pipe, measure down to a point that will allow enough clearance for the removal of the disc in valve H without having the valve wheel hit the bottom of the meter.
29. Subtract from this measurement the distance taken up by the tee and ell fitting.

    The remainder equals the lengths of the two drop pieces E and E_1.
30. Measure from the center of the meter to the center of the tee on pipe A.
31. Subtract from this measurement the distance taken up by ½ of globe valve H and ½ of ell F.

    This gives the length of pipe G.
32. Cut pieces of pipe E, E_1, and G.
33. Thread each end of the pipe.

    Proper threading procedures may be found in Job Sheet No. 1.
34. Screw one piece of pipe E into tee B and tighten with a wrench.
35. Screw ell F on the other end of pipe E.

36. Pull ell tight so that it faces parallel to the supply line A.

37. Screw one piece of pipe G in a valve H.
    The pressure should enter under the valve seat.

38. Screw valve and pipe into ell F.

39. Pull valve tight, checking to see that the stem of the valve is in a vertical position.

40. Screw a piece of pipe E_1, into tee B_1, and tighten with a wrench.

41. Install ell F_1 on the other end of pipe E_1.

42. Screw a nipple in valve H.

43. Start male half of union D_2 on nipple.

44. Tighten the union and nipple.

45. Measure the distance from the center of the union D_2 to the center of ell F_1.
    This is the length of pipe G_1.

46. Cut piece of pipe G_1.

47. Thread pipe G_1.

48. Screw pipe G_1 into ell F_1.

49. Start male half of union on pipe G_1.

50. Tighten the male half of union and the nipple.

51. Spring pipes G_1, and nipple, valve H and pipe in ell F apart so that male end of union fits in female end. Push in place.

52. Connect union D_2 and tighten with a wrench.

QUESTIONS

1. **Explain the purpose of a by-pass.**
2. **What determines the distance of the by-pass line from the supply line?**
3. **Why should the pressure enter the valve under the valve seats?**
4. **Explain the purpose of thread dope.**
5. **What is the distance from center to face of a standard 1″ tee? A 1″ ell? A 1″ globe valve?**
6. **Explain the advantages in using unions when by-passing a meter.**

JOB SHEET NO. 6

TO FIND THE LENGTH OF PIPE FOR MAKING AN OFFSET BETWEEN GIVEN POINTS

General Information

Marine pipefitters are confronted daily with the problem of making offsets to carry pipe lines around, over, and under obstacles of various types. An important factor to remember is that the greater the offset angle, the more the flow within the pipe will be restricted. In cases where the pipe line is to run parallel to its original course, a 45° fitting is used, whenever possible. The following work procedure shows a method of measuring and fitting a length of pipe for an offset between two known points.

Problem

Find the lengths of 3″ pipe needed for making a 45° offset between two given points.

Tools and Equipment	Materials
1. Straightedge	1. Paper
2. Rule	2. Pencil

Procedure

1. Place a straightedge on the center of pipe *A* to align with (Fig. 210) and have it extend in the direction of and beyond the face of the flange on pipe *B*.
2. Align the face of pipe *B* flange at right angles with the straightedge.
3. Measure from the center line of pipe *B* to the edge of the straightedge, or center line of Pipe *A*.

   Check to see that measurement is made at right angles to the straightedge.
4. Record the measurements.

   This distance is the distance of the offset. The distance from the center line of *A* to the center line of *B*, or from *E* to *F* is 2′1″.
5. Multiply the distance from *E* to *F* (2′1″) by constant (1.41) for a 45° elbow. 2′1″ = 25″ × 1.41 = 35¼″.
6. Subtract the space taken up by the two 45° flanged fittings.

   The distance taken up by each 45° elbow is 3″. (Refer to Job Sheet No. 1.)
   3″ +3″ = 6″
   35¼″ − 6″ = 29¼″

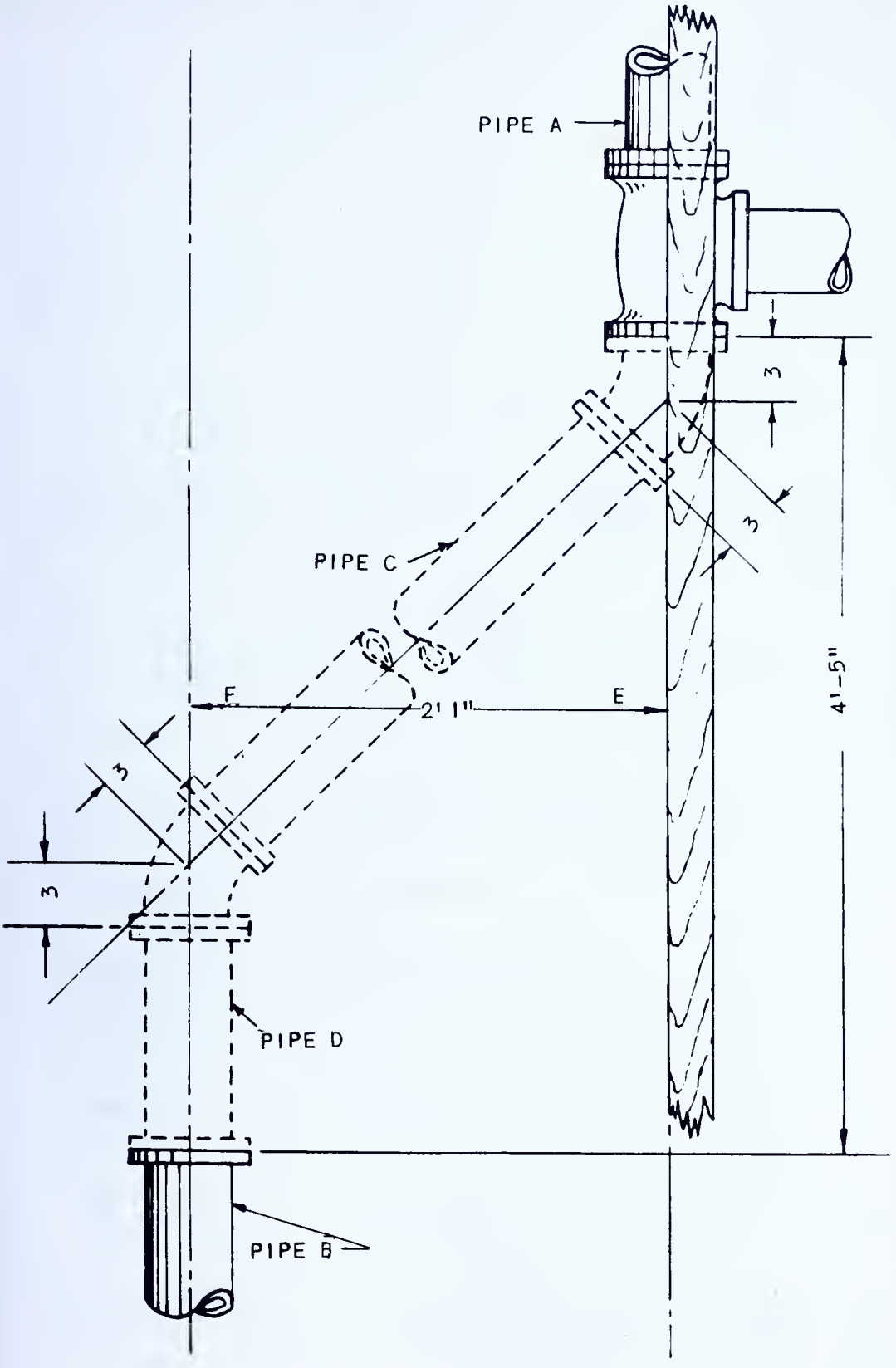


FIG. 210 — *An Offset between Two Given Points*

7. Subtract the space taken up by two $\frac{1}{8}''$ gaskets.
$\frac{1}{8}'' + \frac{1}{8}'' = \frac{1}{4}''$ gasket space. $29\frac{1}{4}'' - \frac{1}{4}'' = 29''$ or $2'5''$

Accordingly $2'5''$ is the length of pipe *C* required to make the $2'1''$ offset shown in Fig. 210.

The following procedure will determine the length of the remaining piece of pipe necessary to complete the piping system.

8. The distance will remain the same from the center line of pipe *A* to the center line of pipe *B* which is $2'1''$.

9. Add the distance taken up by the other halves of the 45° fittings ($3''$ each) to $2'1''$. $3'' + 3'' = 6''$ $\quad 2'1'' + 6'' = 2'7''$.

10. Add the space taken up by three $\frac{1}{8}''$ gaskets.
$\frac{1}{8}'' + \frac{1}{8}'' + \frac{1}{8}'' = \frac{3}{8}''$ gasket space. Then $\frac{3}{8}'' + 2'7'' = 2'7\frac{3}{8}''$.

11. The total distance from the face of flange *A* on pipe *A* to the face of the flange on pipe *B* is $4'5''$. Subtract $2'7\frac{3}{8}''$ from $4'5''$ to get the length of pipe *D*. $4'5'' - 2'7\frac{3}{8}'' = 1'9\frac{5}{8}''$, the length of pipe necessary to complete the piping system.

QUESTIONS

1. **Explain why offsets are used in piping systems.**
2. **Explain why 45° offsets are more desirable than offsets of 90°.**
3. **Where may the measurements for a 45° flanged fitting be obtained?**
4. **Why is it necessary to include the space that the gaskets will take?**
5. **Using the same illustration find the length of pipe needed in making an offset between known points using the following dimensions:**
   a. **Pipe size 3″. The distance from center line on pipe *A* to the center line on pipe *B* is 3′6″. The total distance from the flange on pipe *A* to the flange on pipe *B* is 5′2″.**
   b. **Pipe size $2\frac{1}{2}''$. The distance from the center line on pipe *A* to the center line on pipe *B* is 3′. The total distance from the flange on pipe *A* to the flange on pipe *B* is 4′4″.**
   c. **Pipe size $1\frac{1}{2}''$. Distance from the center line on pine *A* to the center line on pipe *B* is 2′6″. The total distance from the flange on pipe *A* to the flange on pipe *B* is 3′10″.**

JOB SHEET NO. 7
TO FIT A FLANGE ON A PIPE

General Information

When fitting a piece of pipe with a screw flange, it is very important that the pipe and the flange should fit exactly right. It is not enough to pull the flange up until it is tight, but the threaded end of the pipe must come approximately flush with the face of the flange at the same time the flange becomes tight.

At all times flange faces must be perfectly square or a leaky joint will be the result.

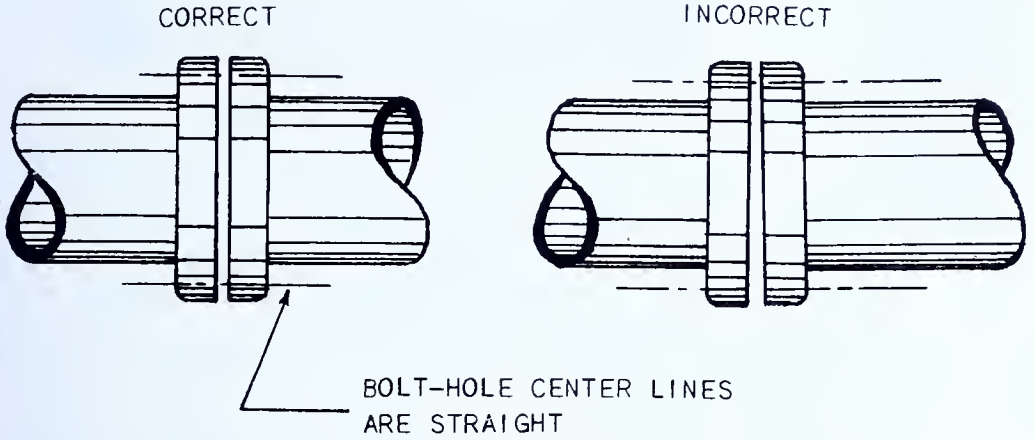


Fig. 211 — *Making a Flanged Joint*

Fig. 211 shows a flanged joint that has been made correctly and one that has been constructed incorrectly.

Flange threads vary, and it is often that standard threads of pipe will not fit a flange. When the pipe threads do not fit the flange, they must be cut to fit. This fitting is accomplished by trying the thread of the flange on the pipe, then cutting the threads of the pipe and trying again until they do fit. This is usually done by a machine operator, but a pipefitter must be able to do his own fitting.

Problem

Fit a flange on a piece of 2½″ pipe.

Tools and Equipment	Materials
1 Pipe dies	1. 2½″ threaded flange
2. Pipe vise	2. 2½″ pipe
3. Flange wrench	3. Thread dope

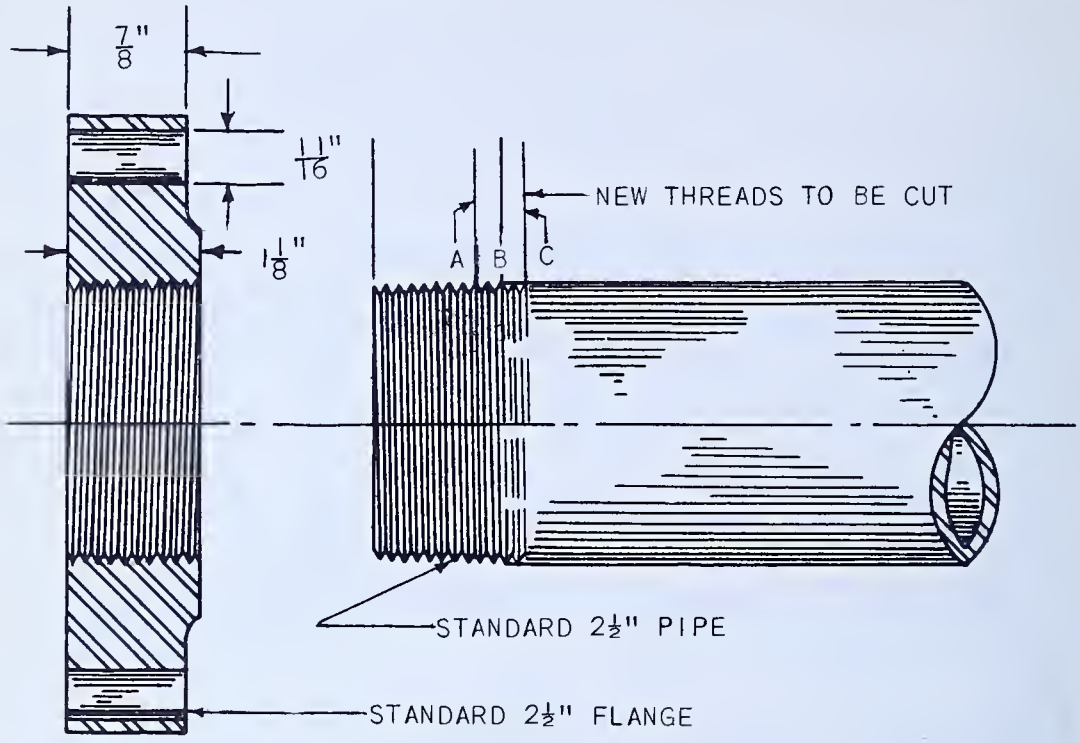


FIG. 212 — *Fitting a Threaded Flange Correctly*

PROCEDURE (When flange fits correctly)

1. Place a length of pipe in the pipe vise.

   If threaded pipe is not available, refer to job for threading procedure.

   Allow enough pipe to stick out through the vise so that the flange wrench or die stock can be rotated without striking the bench.

2. Tighten the vise enough to keep the pipe from turning, but not enough to pinch or flatten the pipe.
3. Apply thread dope to the threads.
4. Screw the flange on the pipe by hand as far as it will go. See point *A* Fig. 212.
5. Secure a flange wrench and place it on the flange.
6. Pull flange tight.

   When the flange is tight, the shoulder of the flange should reach point *B* on Fig. 212. The end of the pipe will be approximately flush with the face of the flange.

PROCEDURE (When flange does not fit correctly)

1. When the flange does not go on far enough (in Step 4), count the number of threads from the face of the flange to the end of pipe. For example, let us suppose there are two threads.
2. Secure the correct size of pipe die and place it on the end of the pipe.

3. Cut two more threads on the pipe to point *C* on Fig. 212.

   Apply cutting oil to threads.

   At the same time that the two new threads are being cut, the old ones are being cut deeper, allowing the flange to screw on farther.

4. Screw the flange on the pipe by hand as far as it will go.

5. Place a flange wrench on the flange and pull tight.

6. If the pipe does not fit, repeat the procedure until it does fit.

   The end of the pipe must fit approximately flush with the face of the flange.

QUESTIONS

1. **What must be done if flange threads do not fit the threads of the pipe?**
2. **Explain the purpose of thread dope.**
3. **Explain why the end of the pipe must be approximately flush with the face of the flange.**
4. **Explain correct method of placing a piece of pipe in a vise.**

JOB SHEET NO. 8
* TO PIPE A LOW-PRESSURE STEAM LINE

General Information

The auxiliary steam line supplies the auxiliary machinery, that is, it does not supply the main engine.

The majority of the ship's machinery is supplied from the auxiliary steam line. The main engine, the electric generators, the fuel-oil service pumps, the whistle, and the smothering-line manifold are, in some cases, the only units operated from the main steam line, i.e., directly from the boilers.

A pressure-reducing valve is installed between the main steam line and the auxiliary steam line. The amount of pressure carried on the line varies to meet the requirements of each ship. In most instances, however, 125 to 150 pounds per square inch is satisfactory. The fittings and pipe in the auxiliary header are flanged. The header is fitted with extra-heavy material up to the reducing valve and standard material beyond the valve.

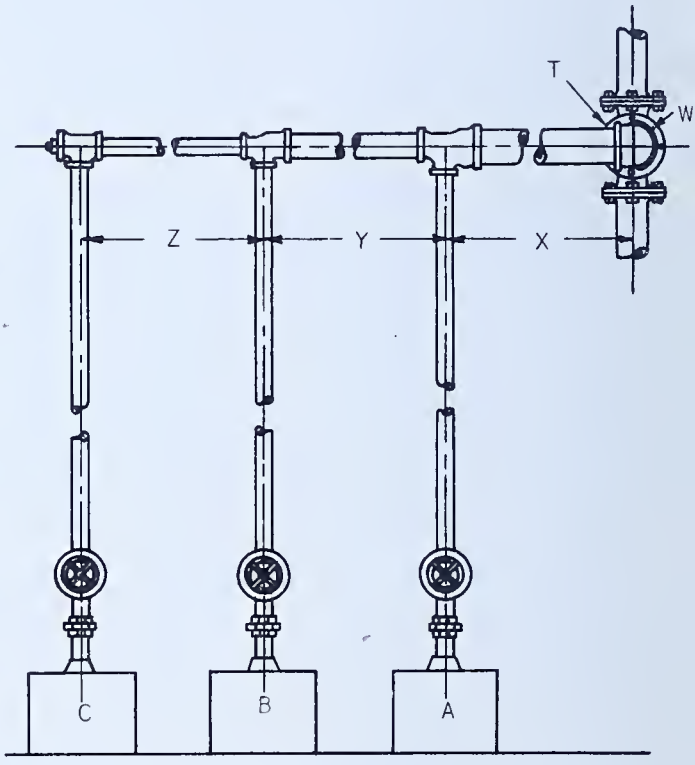


FIG. 213 — *Steam Supply Line*

Standard pipe and malleable screw fittings are quite sufficient in the steam lines branching from the auxiliary steam line to the different pumps and units; 200-pound screw-type valves are used on pipe of 2″ or smaller.

Figure 213 shows a 3″ x 3″ x 2½″ standard flanged tee (T) installed in the auxiliary steam-line header and three pumps, *A*, *B*, *C*, set on their foundations. The job is to pipe steam to the three pumps from the tee in the auxiliary steam line.

*Adapted from "Marine Pipefitting", by State Department of Education, Alabama.

Tools and Equipment

1. 36″ Stillson wrench
2. 24″ Stillson wrench
3. 18″ Stillson wrench
4. Two ⅝″ open-end wrenches
5. Rule
6. Dividers
7. Pocketknife

Procedure

1. Make a simple sketch of the lines and fittings to be installed and mark down the measurements. The sketch will be somewhat similar to Figure 213.

2. Figure the material needed and make out order as follows:
   1 2½″ standard flange
   4 ⅝″ x 2¼″ bolts with hex nuts
   1 pc. of steam pckg., 1/16″ x 7″ x 7″
   1 2½″ ell, blk.
   1 2½″ x 2″ x 1½″ tee, blk.
   1 2″ x 1″ tee, blk.
   1 1½″ x 1½″ x 1½″ tee
   1 1½″ pipe plug
   3 1½″ globe valves for 200-lb. pressure
   3 1½″ unions, blk.
   6 1½″ x 4″ nipples, blk.
   Thread dope

3. Measure the distance from the bulkhead to the center of the 2½″ flange on the 3″ x 3″ x 2½″ tee. Next measure the distance from the bulkhead to the center of the steam opening on pump *A*.

   Subtract the second distance from the first. The remainder is the distance (*X*) center of fitting to center of fitting. Put down the length on the sketch.

4. Measure the distance from the center of the steam opening on pump *A* to the center of steam opening on pump *B*.

   This is distance (*Y*) from center-to-center. Put the length on the sketch.

5. Measure the distance from the center of steam opening on pump *B* to the center of steam opening on pump *C*.

   This is the distance (Z) from center-to-center of fittings. Put the length on the sketch.

6. Obtain a piece of batten wood with one side straight, and long enough to reach horizontally from the center of the 2½″ flange to or beyond a point vertically above the steam opening in pump *A*.

   Hold the wood on a straight line across the face of the 2½″ flange at the flange center. Measure down from the straight edge of the wood to the steam opening in pump *A*. Add enough for the pipe to screw into the pump fitting. The total

distance is the length desired from the center of the tee down to the pump. Mark this length on the sketch. (The drawing indicates that all three pumps are of the same height.)

7. Press the straight side of the batten wood against the face of the 2½″ flange near one end of the batten, and swing the other end down to a position behind, but in line with the steam opening in pump *A*.

   Measure from the center of the steam opening to the straight edge of the batten. This is the distance (*X*) center of ell to face of flange. Put this length on sketch.

8. Procure the listed material from the warehouse and bring it to the pipe shop.

9. Mix up the thread dope, and fasten a 1½″ x 4″ nipple into each half of the union. Then tighten three valves onto three of the nipples. The three separate units of the job will be connected in the same way.

   This is done in order to determine the distance they will take up after being tightened together.

10. Subtract the amount taken up by these fittings and the amount taken up by the fitting in the horizontal part of the line from the length marked on the sketch.

    Cut 1½″ pipe to fit into the length remaining for the drop pieces to the pumps, and cut standard threads on each end of them.

11. Screw the three pieces into the three valves.

12. Figure what the fittings which are used in each distance, *W*, *X*, *Y*, and *Z*, will take up.

    Cut and thread the proper length of pipe as determined by subtracting the amount the fittings take up from the measurements in Steps 3, 4, and 5. Be careful to get the measurements on the right size of pipe. Call the pieces of pipe *W*, *X*, *Y*, and *Z*.

13. Tighten the fittings on the proper threads.

    Pipe *X* has a 2½″ flange on one end and a 2½″ ell on the other. The bolt holes should be two holes straddling the center of the ell. The 2½″ x 2″ x 1½″ tee tightens on pipe *X*. The 2″ x 1½″ x 1½″ tee tightens on pipe *Y*. The 1½″ x 1½″ x 1½″ tee tightens on pipe Z. Tighten the 1½″ pipe plug into the running end of the 1½″ x 1½″ x 1½″ tee. This plugged end will provide an outlet to supply some other piece of machinery at some future time.

14. Take these four pieces of pipe, the three 1½″ drop pieces, and all other needed material onto the ship for installation.

15. Tap out a gasket from the 2½″ flange, and bolt up pipe *X* with the ell facing in the right direction.

16. Tighten pipe *X* into the ell with the 1½″ side opening facing down.

Take one of the 1½″ drop pieces. Undo the union and tighten the nipple into pump A. Tighten the piece of pipe into the tee and catch the nut of the union by hand.

17. Tighten pipe *Y*. Follow the same procedure with pump *B* as with pump *A*.

18. Tighten pipe *Z* and fit the same as with pumps *A* and *B*.

The three valve wheels should be in line with each other to give a uniform appearance to the job.

QUESTIONS

1. **Why are the unions installed next to the pumps?**
2. **What is the proper manner to install the three pump-control valves? Why?**
3. **Draw a sketch showing a 4″ x 3″ x 4″ tee. Mark sizes.**

JOB SHEET NO. 9
* TO INSTALL INTERNAL PARTS OF FOREPEAK SUCTION LINE

General Information

A suction line is installed for the purpose of drawing liquid from a tank. Piping at the pump may be arranged so that the tank can be filled through the suction line. The master valve is inside the tank and is bolted to the bulkhead; at the other side of the bulkhead is number one cargo hold. An extension stem is run (by a machinist) from the valve to the forecastle deck so that the valve may be operated from the deck.

A suction line is run close to the center line and close to the bulkhead. The drop, or tail piece, extends to within 1½" of the ship bottom. If fresh water is carried, no strainer is needed. If oil is carried, a strainer is set on the tank bottom. In most cases 2½" or 3" pipe is used.

The sketch shows only the internal portion of the forepeak suction line. The external part leading to the pump in the engine room is run along the top of the bilge floors or through holes in the bilge floors through Nos. 1, 2, and 3 holds.

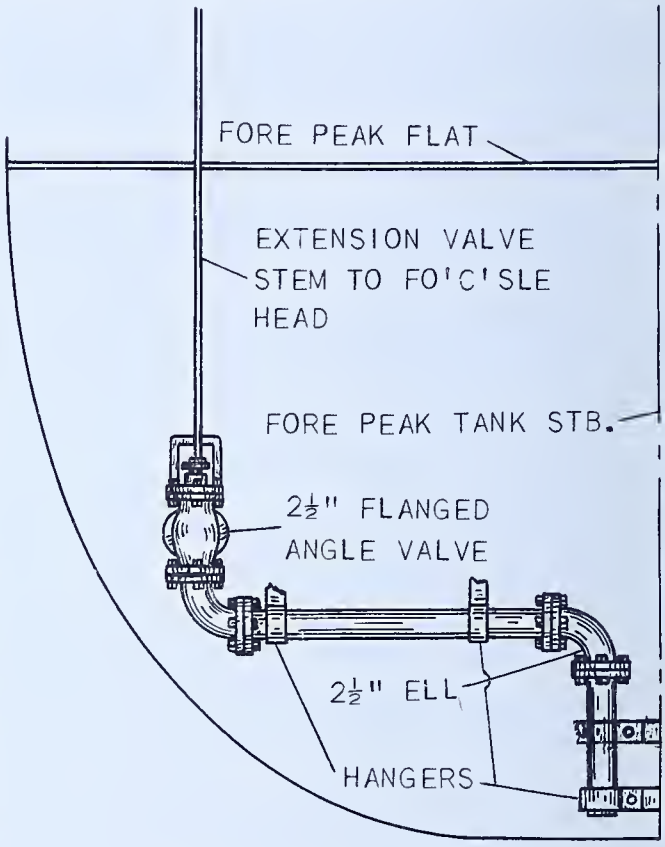


FIG. 214 — *Suction Line Installed*

In order to find the location of the angle valve in the tank (installation starting point), enter No. 1 hold and determine what center on bulkhead will give clearance to run pipe down the bilge. If possible, also allow for clearance of valve extension stem.

Tools and Equipment

1. Hammer
2. Center punch
3. Dividers
4. Rule
5. Pocketknife
6. ⅝" open-end wrenches
7. Burning torch
8. Air motor and drill

*Adapted from "Marine Pipefitting", by State Department of Education, Alabama.

MATERIALS

One 2½″ flanged angle valve	Four ⅝″ bolts
Two 2½″ standard cast-iron flanged ells	Hex nuts
Three 2½″ cast-iron companion flanges	Gaskalac
2½″ standard galvanized pipe	Red-lead powder

PROCEDURE

1. From No. 1 hold, lay off bulkhead for standard 2½″ drilling.

   Burn out center hole, and drill and tap for ⅝″ studs.

2. Screw the four studs into bulkhead.
3. Enter tank and bolt angle valve to bulkhead using full-face gasket, grommets, washers, and nuts.
4. Bolt one of flanged ells to angle valve, with ell facing center line. Use a ring gasket.
5. Measure from face of flange on ell toward center line to point where tail piece will drop.

   Tail piece should drop as close to center line as practical.

6. Subtract from this measurement the space taken up from center to face of second ell.

   This gives length of horizontal pipe.

7. Using some part of the ship structure as a straightedge, put mark on bulkhead at same height as center of the ell that is bolted to angle valve.

   This point should be vertically over the point toward which tail piece will be dropped.

8. Measure from this point to the ship bottom.
9. Subtract from this measurement 1½″ (bottom clearance) and space taken up by the ell.

   This gives the length of pipe for tail piece.

10. Cut, thread, and flange pieces of pipe. Install flanges so the opposite holes in them align with each other.

    The tail pipe has only one end threaded and flanged.

11. Bolt horizontal piece to ell on angle valve, and bolt second ell to the other end with ell facing down.

    Use ring gaskets.

12. Bolt flanged tail piece to ell, using ring gaskets.
13. Measure and make sketch of suitable hangers.
14. Have blacksmith make hangers from sketch, using ½″ x 2″ flat-bar iron.
15. Bolt hangers to pipe, and have welder fasten legs to the ship structure so that the tail pipe is held in position 1½″ off bottom and vibration is eliminated.

QUESTIONS

1. For what purpose or purposes is a suction line installed?
2. Where is the master valve controlling forepeak suction line located?
3. How is location of angle valve determined?
4. From what point, after installation, is the valve operated?

JOB SHEET NO. 10
TO SUSPEND PIPE LINES

General Information

Pipe hangers and pipe supports are fitted on pipes ranging from ⅛″ to 12″ inclusive.

Hangers are fitted on pipe throughout the ship wherever pipes have been installed. All piping must be supported by hangers at not less than 10-foot intervals. The spacing is determined by the size of pipe and the amount of weight involved (weight depends on length of pipe). The location of the hanger also is determined by the size of the pipe. A hanger should be placed close to a valve.

Hangers and Clips

Single-leg hangers are adequate for holding up weight, but they are not so efficient as the double-leg type, for they do not eliminate side movement and serious vibration.

Where pipe lines lie against a series of structural frames, clips can be used. The clip is made to fit over the pipe with a leg extended on one side.

It is common practice to weld rather than bolt the hanger and clip legs. If welding is prohibited, holes are drilled in the hanger, clip legs, and structural frame for bolting the hanger leg to the frame.

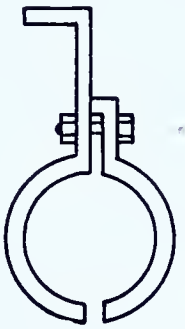


Fig. 215 — *Single-Leg Hanger*

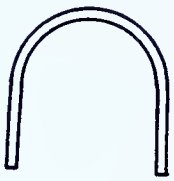


Fig. 216 — *Clip*

Special Conditions

When pipe lines pass through holes in the bulkhead or under angle frames, a twist hanger should be used. When a hanger of this type is used, there is more welding space available than usual.

In most cases the two halves of the hanger should be drawn tight around the pipe so that the pipe will not be chafed by backward or forward movement. Some times the pipe has expansion joints at certain intervals. The hangers which are fitted on these pipes must be made oversize for lead, and clearance must be allowed for expansion and contraction of pipe.

Lead is fitted in this type of hanger to eliminate static electricity which forms when pipe expands and contracts.

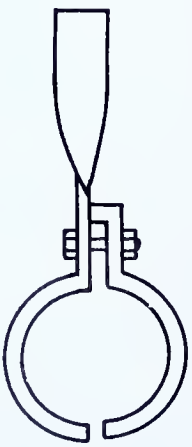


Fig. 217 — *Twist Hanger*

Fitting Lead Wearing Strips

For brass and copper piping throughout the ship the hangers should always be leaded. These pipes usually do not expand or contract, and the hanger must be fitted tightly around the pipe to eliminate all vibration and movement.

Hangers for brass and copper piping are always leaded to keep the hanger from wearing or cutting holes in the pipe. Sheet lead is cut into strips and is then placed

Fig. 218 — *Leaded Hanger*

in the hanger around the pipe. The width and length of the lead is determined by the size of flat bar which is used for the hanger. The lead is tapped into the half circles of the hanger and flanged over on opposite sides.

Allowances for fitting are made as follows when cutting the lead strips:

The width of the iron, plus twice the thickness of the iron, plus ¼″ on each side to be flanged over, plus the thickness of the lead equals the width required for bending the lead over and around the edges of the hanger flat bar.

Flat-Bar Dimensions

The following width and thickness of flat-bar iron is used under ordinary conditions for making hangers:

Size of Pipe	*Thickness and Width of Flat-Bar Iron*
⅛″ to ¼″ Pipe	3/16 x ¾″ Iron
⅜″ ″	3/16 x ⅞″ ″
½″ to 1″ ″	¼ x 1″ ″
1¼″ ″	¼ x 1¼″ ″
1½″ ″	¼ x 1½″ ″
2″ to 2½″ ″	⅜ x 1½″ ″
3″ ″	⅜ x 1¾″ ″
3½″ to 4″ ″	⅜ x 2″ ″
5″ to 6″ ″	½ x 2″ ″
8″ ″	½ x 2½″ ″
10″ ″	½ x 3″ ″
12″ ″	⅝ x 3½″ ″

Pipe Supports

When 10″, 12″, or 14″ pipe is to be hung in the cargo tanks, on deck, or in the pump rooms, the hangers used are called "Pipe Supports" because heavier iron is used and in some instances plates are welded to the supports from one leg to the other. See Figs. 220 to 223. These pipes are reinforced by using angle iron and U bolts.

Flat Bar for Supports

The following material is used in making the above mentioned pipe supports:

Size of Pipe	*Thickness and Width of Flat Bar*
10″ pipe	5/8 x 3½″ iron
12″ to 14″ pipe	5/8 x 4″ iron

Reinforcing the Supports

When angle iron and U bolts are used to reinforce the pipe supports, the following sizes of material are used: Angle: ½″ x 4″ x 4″ U bolt: 1″ round iron.

Procuring Hangers

All of the hangers bent into two half-circles or any curved shape which is to fit the pipe are made in the blacksmith shop. The hangerman takes measurements and makes a sketch of the hanger to be used for the job he is doing. The order must be written on an order sheet giving the hull number of the ship, the item number of the job, the number of hangers desired as per sketch, and the size of flat-bar iron to be used. This order is given to the blacksmith-shop foreman, who will have the hangers made.

Drilling Bolt Holes

The blacksmith makes the hangers, but does not punch the bolt holes in the hangers. These holes are either punched or drilled by the hangerman. All centers are laid out uniformly so that any cap will fit any hanger.

After the hangers are punched and drilled, they are painted according to sizes and lengths, and stored.

Binder Hanger

When it is impossible to weld or bolt a hanger to a substantial angle or structural frame, a binder hanger (Fig. 219) is used. This is a hanger which binds two pipes together; the pipe which is more substantial and solid than the other, helps to support the weaker one.

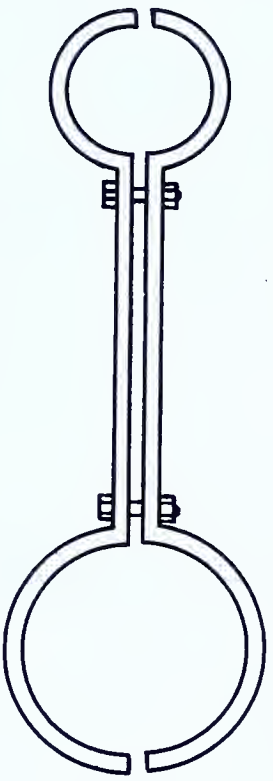


Fig. 219 — *Binder Hanger*

Multiple Supports

When series of pipes run parallel along the deck or bulkhead, a multiple support may be used provided all of the pipes run at a definite center and height. This type of hanger is made up of a series of clips or U bolts on a stand made of flat bar or angle. See Figs. 220 and 221.

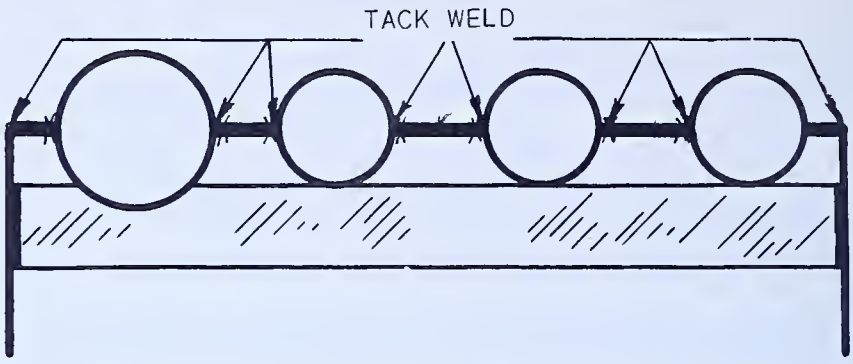


FIG. 220 — *Pipe Supports Used on the 6" Fuel-Oil Transfer and the Stripper Lines*

When piping runs between frames, along bulkheads, or in quarters where metal has been installed on Rock Wool insulation, the supports must be fastened to the sheet metal with sheet-metal screws, through the foot of the support. One or more screws are used.

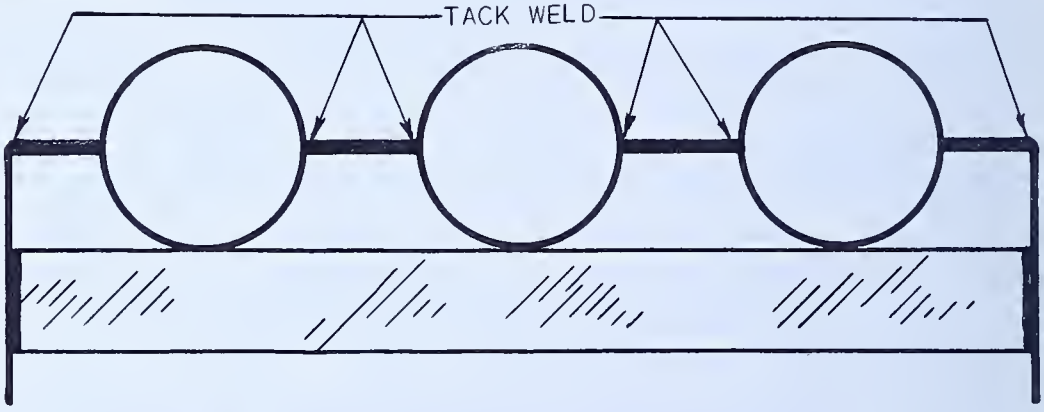


FIG. 221 — *Pipe Supports Used on the Deck Cargo Lines*

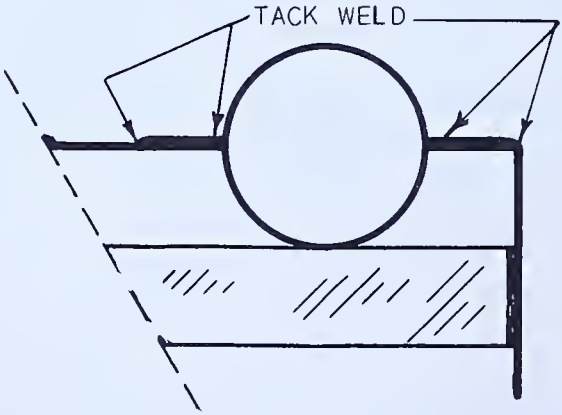


FIG. 222 — *Supports Used in Tanks Where One Leg Welds against a Flanged Stiffener on the Transverse Bulkhead*

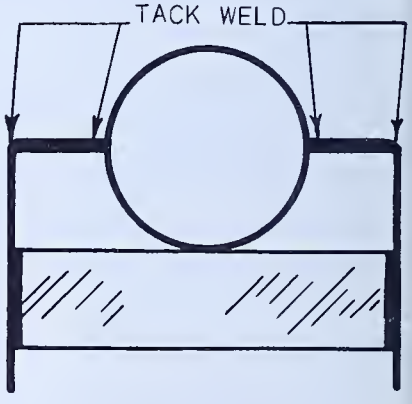


FIG. 223 — *Supports Used in the Tanks on the Transverse Lines*

PROCEDURE

1. Take the measurements on board ship to determine the size and number of hangers desired.
2. Make a sketch of the type of hanger needed on an order sheet together with number needed and specifications for construction.
3. Have the blacksmith make the hangers.
4. If the blacksmith shop is overloaded with work, have the necessary pieces of bar cut to size in the pipe shop. Then have the bolt holes punched in the proper places on the bars. This can be done on the combination punch and cutoff machine.
5. Bend the bars to the proper shapes on the hydraulic bending machine.
6. Check with the specifications to see if the hangers are to be lined with lead. If they are to be lead-lined, cut out the sheet lead and beat it over the inside of the hangers.
7. Take the hangers to the ship and locate them in their proper positions.
8. Have the hangers welded.

QUESTIONS

1. **What size of material should be used to make hangers for 2″ pipe?**
2. **Where are these hangers usually made?**
3. **In what way is the double-leg hanger superior to the single-leg hanger?**
4. **Why should the hanger be clamped tight around the pipe?**
5. **Explain the proper method of installing hangers on a brass pipe.**
6. **Why are some hangers lined with lead?**
7. **Why are some hangers made oversize?**
8. **When is a binder used?**
9. **When is a multiple hanger used?**
10. **How are hangers fastened to sheet metal?**

JOB SHEET NO. 11
* TO MAKE A WATERTIGHT JOINT

General Information

Making a watertight joint between a flange and a bulkhead or a flange and a tank is one of the jobs of a marine pipefitter. Many tanks have pipe lines below the liquid level of the tank; consequently if bolt and studs are not properly installed leaks may occur. For this reason grommets are used on both sides of the stud or bolt holes.

The grommet in this case serves as a gasket in that it is used to make a watertight joint around a stud or bolt hole. Lampwick is used as grommet material, for when it is placed around a bolt or stud under a washer it packs very tightly around the bolt and makes a watertight joint. When bulkhead joints or shell-of-ship joints are made, grommets are sometimes painted with white or red lead to assure a watertight joint. Where bolts are used, the grommets are placed only on the threaded end. Grommets for the head end are made by wrapping the proper length of wick around the bolt after the washer has been placed on the bolt. The length of the grommet material (lampwick) is determined by the size of the stud or bolt. For example, a ½″ stud or bolt will require approximately 18″ of wick, and a ⅝″ stud or bolt will require approximately 30″ of wick.

Problem

Make a watertight joint between a flange and a tank top.

Tools and Equipment	Materials
1. Knife	Ball of lampwick
2. Rule	½″ washers
3. End wrenches	½″ hex nuts
	2—½″ full-face gaskets

Procedure

1. Cut enough lampwick to make a gasket for a ½″ stud.

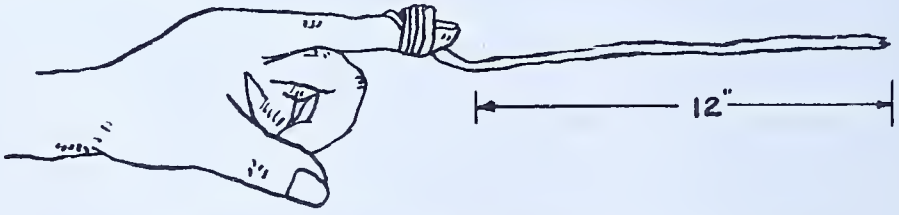


Fig. 224 — *Winding the Wicking on the Finger*

*Adapted from "Marine Pipefitting", by State Department of Education, Alabama.

NOTE: Cut as many pieces as are necessary for the job. Each stud will require two 18″ lengths of lampwick.

2. Wrap the wick around the forefinger about four times.
   NOTE: This will leave approximately 12″ of lampwick. Fig. 224.

3. Remove the lampwick from the finger. Fig. 225.

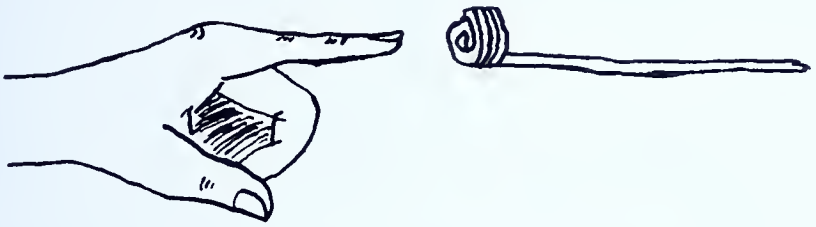


FIG. 225 — *Coils Made and Wicking Removed*

4. Take the free end of the lampwick and pass it through the ring until the circumference of the ring is completely covered. Fig. 226.

5. Pull the wick tight to make the grommet smooth. Fig. 227.

6. Make enough grommets to complete the job.
   NOTE: Figure 228 shows the construction of a watertight joint on a tank. It is taken for granted that holes have already been drilled and tapped, and that the studs are in place.

7. Install four grommets on each stud on the inside of the tank.

8. Install four washers on each stud.

9. Install four hex nuts on each stud and pull tight with a wrench.

10. Place a gasket on the studs on the outside of the tank.

11. Install flange on studs.

12. Install grommets, washers, and nuts on the studs.

13. Pull nuts tight with a wrench.

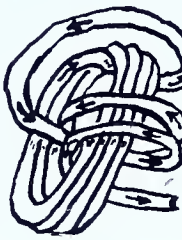


FIG. 226 — *Wrapping the Ring*

FIG. 227 — *The Finished Grommet*

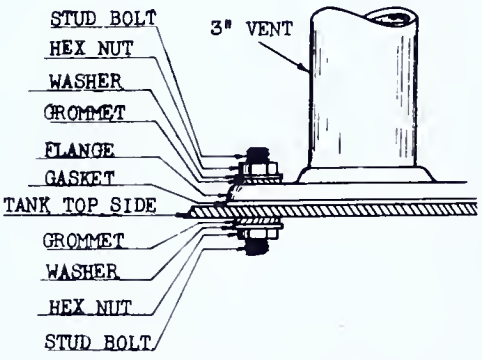


FIG. 228 — *Watertight Joint Assembly*

QUESTIONS

1. Why is white or red lead sometimes painted on the grommet?
2. Explain the difference in the use of grommets on bolts and studs.
3. Explain why a washer is placed between the nut and the grommet.
4. What determines the length of the wick to be used for a grommet?
5. What danger is there in regard to pipe connections on tanks when the connections are below the level of the liquid? Why?
6. Explain what happens to the grommet when the nut is pulled down tight.

JOB SHEET NO. 12
TO MAKE A FULL-FACE GASKET

General Information

A gasket is a thin sheet of composition or metal used in making a flanged joint tight. There are many types and brands of gasket material, and the marine pipefitter should be qualified to determine what type he must use on his job.

Tools and Equipment	Materials
1. Machinist's hammer	Flange
2. Pocketknife	Gasket material

Work Procedure

1. Place flange face up on the work table.
2. Secure the correct type of gasket material.
3. Cover the flange completely with gasket material.
4. With pressure of the thumb locate a hole in the flange.
5. With the ball end of a ball-peen hammer, tap the gasket material over and around the edges of the hole so that the hole edges in the flange cut the material. (A gasket-hole punch can be used for this purpose. The instructor will explain the uses of the gasket-hole punch.)
6. When one hole has been cut, place a bolt in it so that the material will not slip out of position. Refer to *A*, Fig. 229.
7. Locate and cut the bolt hole *B* opposite the hole already cut.

   The same procedure applies to a gasket having any number of bolt holes.

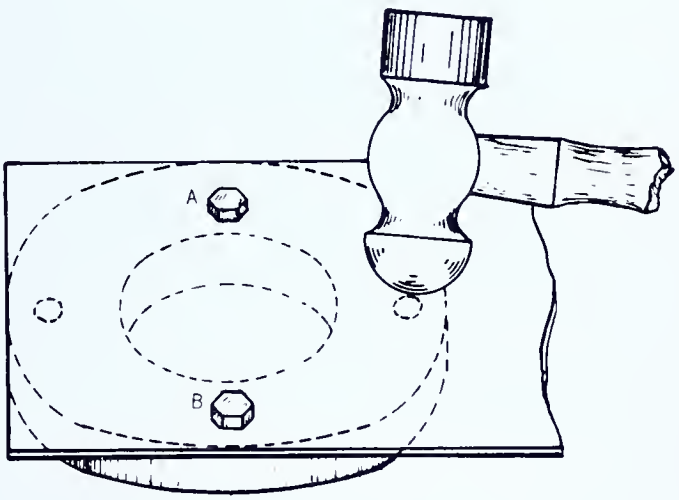


Fig. 229 — *Cutting Bolt Holes with a Ball-Peen Hammer*

8. Place a bolt in this second hole.
9. Locate the remaining holes and cut as indicated in preceding steps.

10. Now use the flat head of the hammer, and tap the material over the inside and outside edges of the flange.

    CAUTION: Tap only hard enough to make the flange edges mark the material.

11. Remove gasket material from flange.

12. Using a pocketknife, cut the outside circle as marked on the material.

    Follow this procedure only if the gasket material is rubber or a material easily cut with a knife.

13. Cut the inside circle with a pocketknife. Make the circle approximately $\frac{1}{8}''$ smaller than the mark.

    NOTE 1: This inside cut is to cover the thickness of the pipe wall where it comes flush with the face of the flange. If the pipe is extra heavy, the hole should be cut approximately $\frac{1}{4}''$ smaller.

    NOTE 2: If the material is too hard to cut with a knife, the inside and outside diameters should be cut in the toolroom on a gasket cutter.

QUESTIONS

1. **What is the reason for placing bolts in the holes as soon as they are cut in the gasket material?**
2. **Why must the correct types of gasket material always be used for the job?**
3. **Why must the gasket fit perfectly?**
4. **Do the holes and the edges of the gasket just made, correspond to the holes and edges of the flange face?**
5. **Why should a pipefitter know how to cut his own gaskets?**

JOB SHEET NO. 13
TO MAKE A RING GASKET
FOR A STANDARD FIVE-INCH FLANGE JOINT

General Information

For information regarding types of gasket material refer to Pages 98 and 99. Ring gasket, or ring joint, is the shipyard pipefitter's term for a gasket that fits the flange faces only, inside the bolt circle. Ring gaskets should be used on all joints except the following:

1. Do not use a ring joint between two thin flanges as they will warp or "dish out" if the bolts are pulled too tight.
2. Do not use ring joints in brass flanged joints as the brass flange will "dish" very easily.
3. Exercise care when using a ring joint between cast-iron flanges as the flange might crack if bolts are pulled too tight.

   Note: Ring joints may be used on all systems not mentioned above as they are more readily tightened and hold better than full joints.

The outside diameter of the ring gasket should equal the diameter of the circle made by the inside edges of the bolt holes, and the center hole should equal the size of the pipe used.

The following table will enable the marine pipefitter to determine the size of ring gasket needed for joints using a class 125 cast-iron pipe flange:

Table No. 11

AMERICAN STANDARD CLASS 125 CAST-IRON PIPE FLANGES

NOMINAL PIPE SIZE	DIAMETER OF FLANGE	DIAMETER OF BOLT CIRCLE	NUMBER OF BOLTS	DIAMETER OF DRILLED BOLT HOLES	SIZE OF RING GASKET
1	4-1/4	3-1/8	4	5/8	1 X 2-5/8
1-1/4	4-5/8	3-1/2	4	5/8	1-1/4 X 3
1-1/2	5	3-7/8	4	5/8	1-1/2 X 3-3/8
2	6	4-3/4	4	3/4	2 X 4-1/8
2-1/2	7	5-1/2	4	3/4	2-1/2 X 4-7/8
3	7-1/2	6	4	3/4	3 X 5-3/8
3-1/2	8-1/2	7	8	3/4	3-1/2 X 6-3/8
4	9	7-1/2	8	3/4	4 X 6-7/8
5	10	8-1/2	8	7/8	5 X 7-3/4
6	11	9-1/2	8	7/8	6 X 8-3/4
8	13-1/2	11-3/4	8	7/8	8 X 11

PROBLEM:

Make a ring gasket for a standard five-inch flange joint.

Bolt circle is 8½″ in diameter; bolt holes are ⅞″ in diameter; outside diameter of ring gasket is 7¾″; inside diameter of ring gasket is 5″.

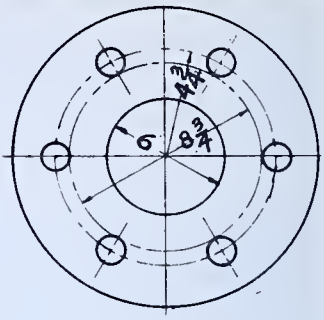


FIG. 230 — *A Ring Gasket*

TOOLS AND EQUIPMENT	MATERIALS
1. Dividers	Gasket material
2. Rule	8″ x 8″
3. Pocketknife	

WORK PROCEDURE

1. The pipe diameter is 5″. Set the dividers to 2½″.
2. Place one point of dividers in the center of gasket material. Press down firmly so that the point cannot slip.
3. With the other point, make a circle 5″ in diameter as shown in Fig. 231.
4. To get the outside diameter of the gasket, refer to Table No. 11 for the dimension of the ring joint which is 5″ x 7¾″.
5. Set dividers for 3⅞″, which is ½ of 7¾″.
6. Place one point of the divider in the center of the 5″ circle already marked and press firmly so that the point cannot slip.

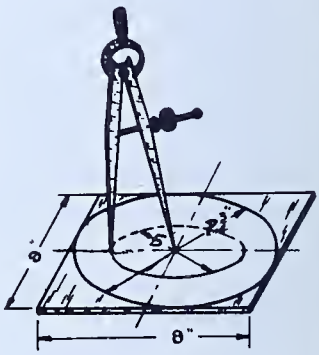


FIG. 231 — *Laying Out a Ring Gasket*

7. Make a circle with the other point to get the outside diameter of the ring gasket. See Fig. 231.

NOTE: If a table giving the dimensions of the ring gasket is not available, the following should be remembered:

1. The outside diameter of the ring gasket should equal the diameter of the circle made by the inside edges of the bolt holes.
2. The center-hole diameter should equal the center-hole diameter of the pipe used.

8. Use a sharp pocketknife; cut out the gasket on the lines marked with the dividers.

QUESTIONS

1. Are ring gaskets used on all types of joints?
2. Name a few cases where ring gaskets are not to be used.
3. Does the center hole of the ring gasket fit a standard 5″ piece of pipe?
4. Does the outside diameter of the ring joint fit within the bolts of the flanges? (Place bolts in flange to test fit of gasket.)

JOB SHEET NO. 14
TO USE A HAMMER AND A CENTER PUNCH

General Information

Purpose of a ball-peen hammer — The ball-peen hammer is used by the marine pipefitter for a number of things, such as making center-punch marks, tapping bolts home, chipping with a cold chisel, driving pins in and out, making gaskets, and for many other purposes.

The chief reason for listing the above operations is to fix in the mind of the student the fact that a hammer has a definite place on the job. The use of a bolt, a bar of steel, or other makeshift should never be considered. Always use a hammer.

Purpose of a center punch — The center punch is used by the pipefitter chiefly to lay out holes on the deck for the burner, mark pipe for saddles to be cut by the burner, line up flanges for rolling machine, mark pipe for cutting off (when burner is to make the cut), and many other purposes.

Correct use of a hammer — If one holds a hammer in his hand for a moment, it is apparent that one can see that the handle is evenly balanced in the head. The length of the handle may vary, to suit the individual, but the hand should always grasp the handle close to the outer end and not at the head end. Holding the hammer close to the head is called "choking" the hammer. This is bad practice and causes accidents.

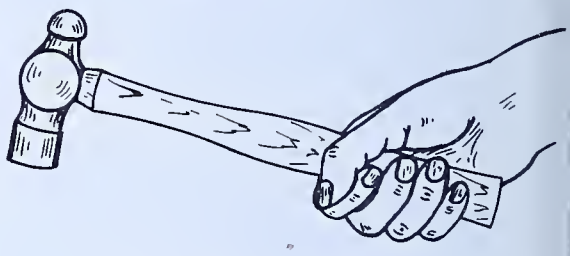


Fig. 232 — *Correct Position to Hold Hammer*

Safety in using a hammer —

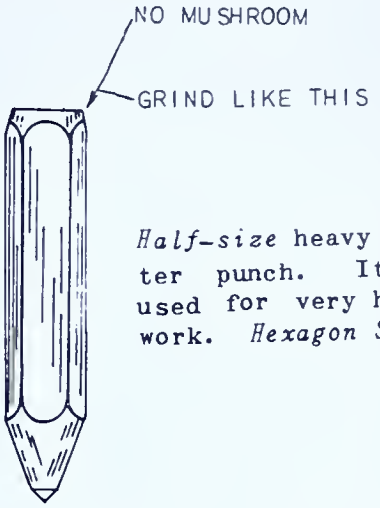
1. Never strike a hardened surface with a hammer. The face and the peen of the hammer are hardened, and two hardened surfaces striking together with force may cause the hammer to "spall"; that is, small chips will crack and fly off. These bits of steel can cause eye injury or cuts.
2. Never use a hammer with a loose handle or a loose wedge. The wedge is in the hammer end of the handle to hold the handle tightly in the head.
3. Never use the handle as a lever with which to pry or to lift.

The center punch — The ordinary center punch (or prick punch) used by the marine pipefitter is shown in Fig. 233. It has a hardened point and a knurled body. The knurled surface gives a better gripping surface for the fingers. Center-punch sizes are given by letter in tool catalogs. Many pipefitters, however, dress

Fig. 233 — *Center Punch or Prick Punch*

their center punches to suit their own requirements. A center punch used for heavy work is shown in Fig. 234. This is a half-size heavy center punch, for use with very heavy work. It is generally made of hexagon steel. Repeated hammering "mushrooms" the head of the punch. Grind the mushroom off before it spalls and causes injury. See Fig. 235 for an illustration of good practice.

The prick punch is smaller and shorter than a center punch. In striking the punch with a hammer, keep the punch straight up and down. A heavy blow will break the point of the prick punch, and may cause the mark to be "off center".



Half-size heavy center punch. It is used for very heavy work. *Hexagon Steel.*

FIG. 234 — *Half-Size Center Punch*

TOOLS AND EQUIPMENT

1. Ball-peen hammer
2. Center punch

MATERIALS

Scrap stock
(plates, pipe, etc.)

WORK PROCEDURE:

(As a hammer and center punch are used frequently, this operation is chosen to describe briefly the correct procedure. The instructor may assign trainees to mark off a saddle, lay out holes for the burner, mark pipe for the burner to cut off, etc.)

1. Secure material and mark off with lines according to instructions.
2. Secure hammer and center punch.
3. Check point of center punch to see that it is ground correctly, and examine the head to see that it is not "mushroomed".
4. Hold the center punch square with the work unless it is necessary to "draw" the punch mark. See Fig. 236 at *B*.

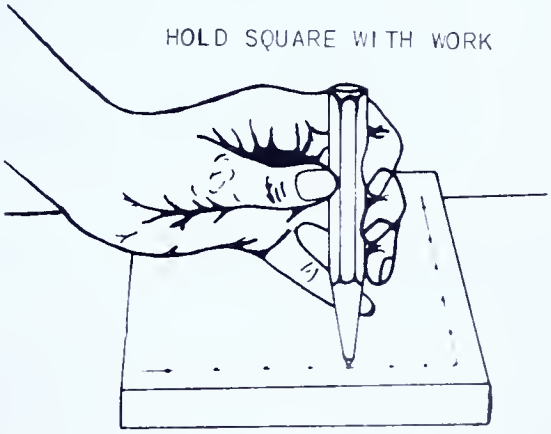


FIG. 235 — *Using the Little Finger to Steady the Punch on the Work*

NOTE: When using a heavy center punch, strike a light blow first to be sure the mark is "on center". Then set the mark deeper with a heavier blow.

5. Continue to lay out piece on lines.

NOTE: One blow with the right weight of hammer is all that is necessary in the majority of cases. Do not use a light hammer on a heavy punch.

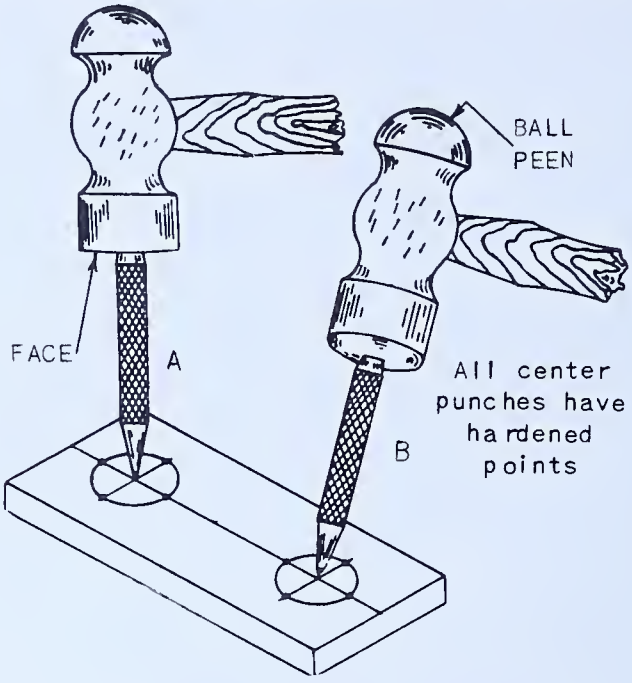


FIG. 236 — *Using a Prick Punch*

QUESTIONS

1. **State the correct way to hold a hammer. Why?**
2. **State some safety precautions that must be followed in using a hammer.**
3. **What condition will result from repeated use of a center punch?**
4. **Why is this dangerous?**
5. **Explain why a hardened surface should never be struck with a hammer.**
6. **How is the size of a center punch determined?**
7. **What is the difference between a prick punch and a center punch?**
8. **Why do punches have hardened points?**
9. **What is likely to happen to a prick punch if it is struck with too heavy a blow?**

JOB SHEET NO. 15
TO USE A PORTABLE GRINDER

General Information

A portable grinder is used to a considerable extent to expedite the work of the marine pipefitter. It is used to smooth ends of pipe that have been burned and the end of pipe that protrudes from the face of a flange, to make beveled (or *v*) edges on pipe or fittings that are to be welded, to make saddles for fittings, etc.

The tool is driven by an air motor which receives a steady supply of compressed air through a heavy rubber hose attached to the handpiece of the grinder. Figure 237

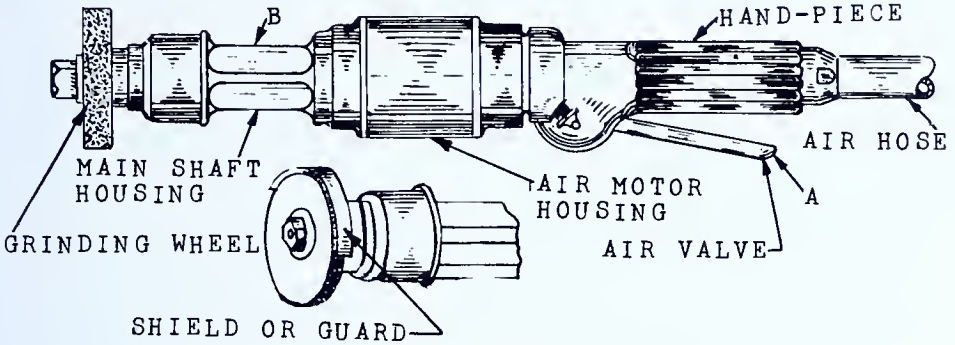


Fig. 237 — *Portable Grinder*

shows an air valve at *A* between the housing and the air hose. The position of this air valve makes it easy for the operator, by a touch of the thumb, to admit or cut off the air instantly.

The grinding wheels used are about 1¼″ to 1½″ thick, and 6″ to 8″ in diameter. Care must be exercised to use a wheel of the correct grade and grit for the job. The grade of wheel used for steel is not generally used for cast iron. Check with the leader or foreman about the correct grade of wheel to use.

Clearing the Line — Before attaching the air hose, clear the line by turning on the air at the main valve. This will blow out any water or dirt that may have collected in the line. If the motor slows up or sticks, application of a little light machine oil will clear the valves. Disconnect the air hose from the hand-piece, pour a little machine oil into the opening, replace the air hose, and blow out to clean the mechanism.

Safety Precautions

When the grinder is laid down on the floor or deck, never move the air control valve. Moving the valve may make the grinder roll and drop into some open place where it could very easily cause serious injuries to others working below. Never

attempt to take a portable grinder apart if it seems to need repairing. Such work is done in the toolroom. Report to the leader at once if the machine fails to work properly.

PROBLEM: Use a portable air grinder.

TOOLS AND EQUIPMENT	MATERIALS
1. Portable air grinder	Scrap pipe
2. Bench vise	
3. Goggles	

WORK PROCEDURE (Operating the grinder)

1. Secure a piece of scrap pipe having a rough edge.
2. Fasten pipe in a pipe vise or bench vise.
3. Determine the type of pipe and check with instructor to see that the correct grinding wheel has been selected.
4. Before attaching the air hose, clear the line by turning on air at the main valve.
   NOTE: This removes dirt or water that might have collected in the line.
5. Connect air hose to portable grinder.
6. Turn on air at the main valve.
7. Test grinder by pressing air valve on grinder handle.
   NOTE: If grinder fails to function properly, report it to the instructor.
8. Keep one hand on the handle for ready control of the air valve; when the valve is released, the wheel stops. Fig. 237 at *A*.
9. Place other hand so that it grasps the neck between the grinding wheel and the motor housing. Fig. 237 at *B*. This allows better control in guiding the machine over the work.
10. Grind end of pipe in vise.
    NOTE: It is not necessary for the operator to "lay on" the machine to make it grind. If too much weight is applied, the wheel will slow down and as a result less work will be accomplished. Maintain a steady, even pressure while the machine is kept moving slowly back and forth to remove stock quickly and do a good job.
11. Grind end of pipe until it is smooth
12. Check for squareness. Use a square.

QUESTIONS

1. Name a few jobs where the pipefitter can use a portable grinder.
2. Why is the machine called a portable grinder?
3. What should be done if the grinder needs repairing?
4. Does it make any difference what type of grinding wheel is used on steel? On cast iron? Why?
5. Why is it good practice to clear the line before using the grinder?
6. Where are the hands placed while operating the grinder?
7. Does "laying on" the machine, while grinding, hurry the job?
8. What is the best procedure to remove stock quickly and smoothly?
9. Name a few safety precautions that should be observed when one uses a portable grinder.

JOB SHEET NO. 16
TO SET UP AN AIR DRILL

General Information

Air Motor and Hose — The air motor as shown in Fig. 238 *a* may be used for drilling, reaming, grinding, boring, and other operations that require the use of a portable rotating tool. One section of the handle is turned to start or stop the motor. The lead hose *b* (also called the whip) is a six-foot length of hose with one connection threaded to screw into the motor handle. The other end of the hose has a universal coupling. The air hose is made of braided cord and rubber. The rubber should be tough and oil-resistant. The universal air-hose couplings, combination male and female, are attached at each end.

Rigging an Air Motor: To rig an air motor, screw the threaded end of the lead hose into the motor handle and couple the other end of the air hose to manifold connection.

Drill Feed: The feed wheel *f* is made on a long shaft *g*, which is threaded into the body of the air motor. The upper end of this shaft is placed under the arm of an "old man"; and when the wheel is turned, the shaft screws out of the body of the motor, forces the motor down, and puts pressure on the drill.

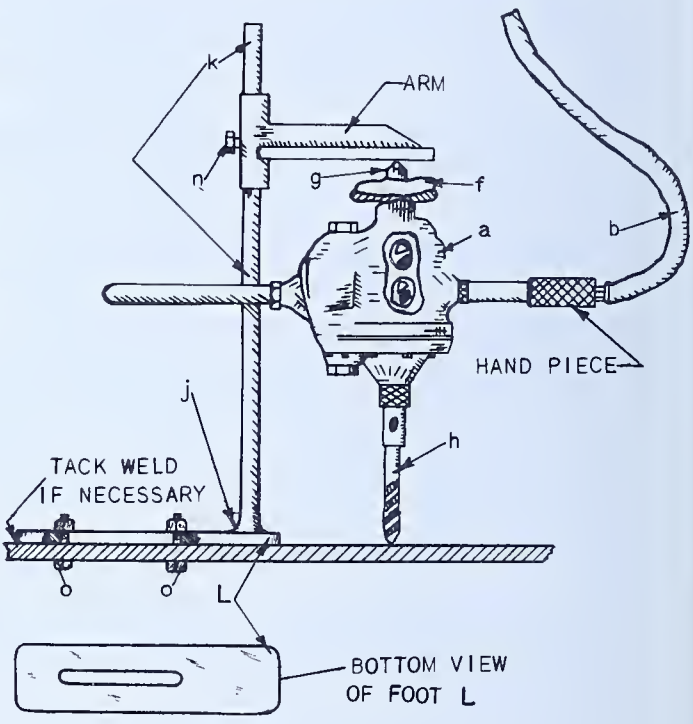


Fig. 238 — *Using a Portable Air Drill With Ratchet and Old Man*

The feed wheel may be turned the other way far enough to cause the lower end of the shaft to force the taper drill *h* from its socket. Care should be taken that the feed wheel raises shaft *g* high enough to allow drill *h* to seat properly before starting to drill. There should be a small space between the upper end of the drill and the lower end of shaft *g*.

Drilling Post — A drilling post, commonly called an "old man", is a tool used to assist the operator of a drill in forcing the drill through the material. See *k*, Fig. 238.

The foot *L* is slotted lengthwise. A bolt is placed in this slot to clamp the foot to

the material. The post *j* is screwed or welded into the foot. The arm may be raised or lowered on the post and clamped at any height or angle around the post by clamp bolt *n*. The underside of the arm has many small countersunk places to fit the tapered end of a drill-feed post.

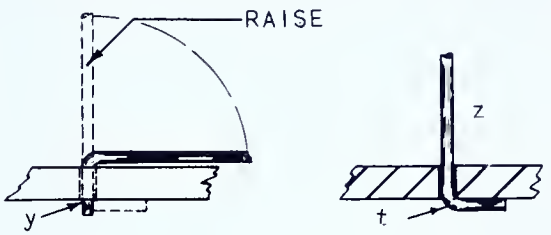


FIG. 239 — *Holding with Bent Bolt*

Drilling Stick — Instead of using an "old man", a "stick" is used on many jobs to apply the feed to an air drill. Figure 240 shows a stick in use.

The "stick" is made in the carpenter shop and sometimes will serve for several jobs. It should be laid away for future jobs until after repeated use it becomes unfit for service. Figure 239 shows how the bolt is bent to act as one end of a clamp and placed through a convenient hole. See Fig. 299 at *t*. The rod is put through the hole in the plate as at *y* and raised to a vertical position as at *z*. The nut is adjusted to the correct height to obtain the maximum pressure.

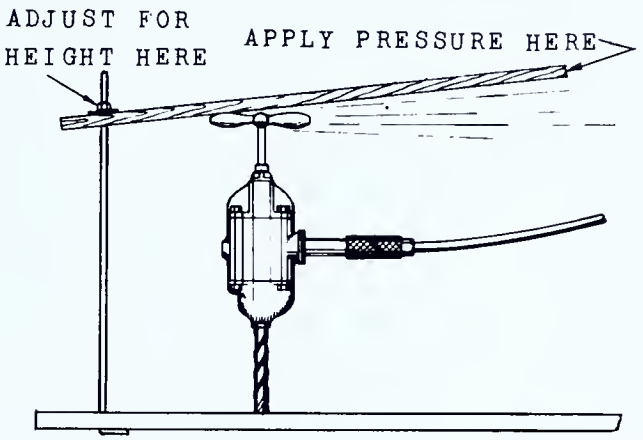


FIG. 240 — *Using a Drilling Stick*

PROBLEM: Set up an Air Drill.

TOOLS AND EQUIPMENT

1. Drilling foot
2. Air motor and equipment
3. C clamp

MATERIAL

Oil

PROCEDURE (Using a Drilling Post)

1. Place foot *L* across the hole of the plate. See Fig. 238.
2. Clamp the foot of the plate, using a C clamp or other clamp device.
   If there is a hole conveniently located in the plate, use it.
3. Place bolts marked *O* through the slot of the foot and the hole in the plate, and tighten securely. This clamps the "old man" to the plate.
   When a C clamp will not reach and there are no holes which may be used for bolting down, tack weld a bolt to the plate for clamping down the foot of the "old man".
   CAUTION: See that the weld is removed after the job is finished.
4. Place the drill in position to drill the hole.
5. Swing arm around over the top of the drill, and fit the tapered end of the feed post into a countersunk hole in the arm.

The arm has many of these holes and the one that lines up with the feed post is the correct one. If a hole in the arm does not line up with the tapered end of the feed post, move the foot *L* to bring a convenient hole in vertical line with the point of the drill. See Fig. 238.

6. Clamp the arm in position with clamp bolt *n*.
7. Turn the feed wheel and press the drill firmly into place.
8. Oil the drill point and start to drill.
9. Turn the feed wheel slowly while the drill turns, until the hole is drilled.

NOTE: While drilling, check to see that the drill lines square with the work.

PROCEDURE: (Using a Drilling Stick)

A drilling stick is used in many cases in place of an "old man".

1. Bend a rod as shown in Fig. 239.
2. Place rod in a hole in the plate and raise to a vertical position.
3. Install nut on threaded end of rod.
4. Adjust nut to correct height to obtain the maximum pressure.
5. Place drill in position with the "stick" resting on top of the drill.
6. Turn the feed wheel and press the drill firmly into place.
7. Oil the drill point and start drilling.
8. Check to see that the drill is perpendicular to the work.

QUESTIONS

1. **Why is an air drill used?**
2. **What is the reason for using an "old man" with an air drill?**
3. **When is the foot of the "old man" tack welded to the plate or deck?**
4. **What is the purpose of a drilling stick?**
5. **Why is it necessary to have a drill ground correctly?**
6. **Name several parts of an air drill.**

JOB SHEET NO. 17
TO TAP A HOLE FOR A HALF-INCH STUD

General Information

Tap sets — Hand taps are made in sets of three:

1. Taper tap (tapered for 5 or 6 threads)
2. Plug tap (tapered for 3 or 4 threads)
3. Bottoming tap (corners of leading threads chamfered)

When starting to tap a hole, keep the tap square with the face of the work, or if the hole is on a slant, keep the tap square with the center of the hole. After 3 or 4 turns, check the direction of the tap by "sighting" from the front and side. Be careful to bear easy or the tap will break. When tapping holes, dip the tap in white or red lead. Lead is heavier than cutting oil, and will make a smoother thread. Lard oil is sometimes used when lead is not available. Tap wrenches may be of the single-handle or double-handle type.

Caution: Never force a tap. Remember they are hardened, and will snap off easily if forced. Be careful when approaching the bottom of a blind hole. Small taps will snap off much more quickly than the larger sizes. Getting a broken tap out of a hole is difficult, wastes a lot of time, and sometimes spoils the hole completely.

When tapping cast iron, use a "dry" tap. A little white lead on the threads at the shank end of the tap will make the tap work easier in the threads already cut. For brass and copper use turpentine and lard oil. For aluminum use kerosene and lard oil.

Problem: Tap a hole for a ½" stud.

Tools and Equipment	Materials
1. One set of ½" taps	1. Tap dope
2. One tap wrench	2. Piece of plate material with 27/64" holes drilled in it.

Work Procedure

1. Dip the taper tap in white lead.
2. Place the tap wrench squarely on top of the tap.
3. Insert taper end of tap in hole.
   Square it with the surface in which the hole is to be tapped.
4. Apply pressure against the tap and turn tap wrench to the right.
   Care must be exercised to see that the tap starts properly.

5. After the tap is started and as the tapping continues, turn the tap wrench backward a half-turn after every full turn ahead.

   This will make the tapping easier, and it will give a smoother thread.

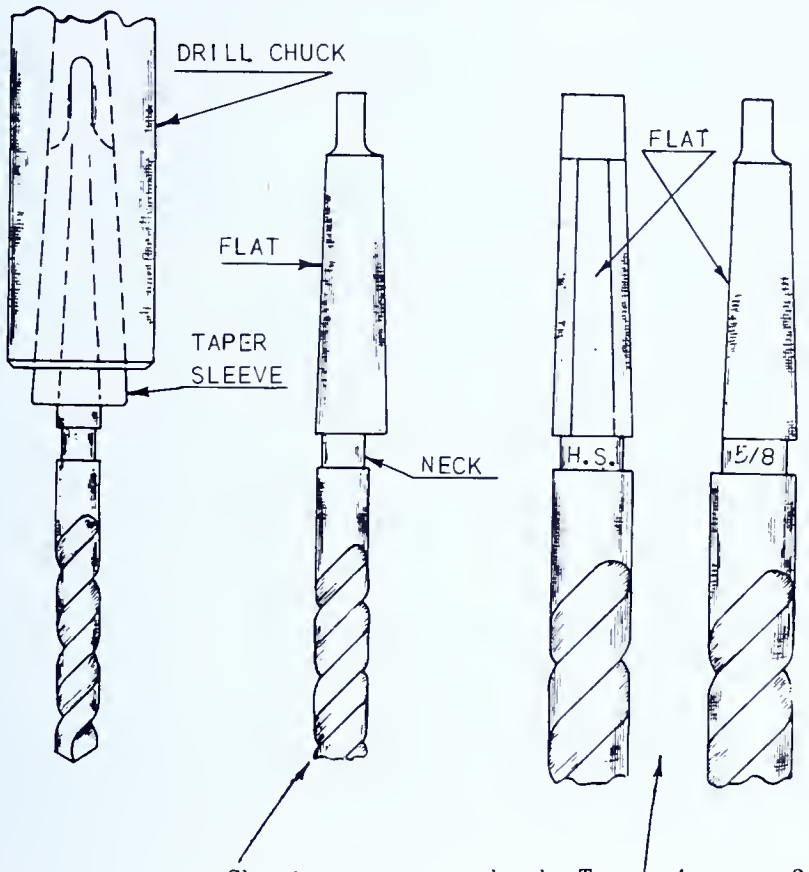
6. Proceed in this manner until the top of the tap is nearly flush with the top of the hole.

   A taper tap is all that is necessary to use if the plate is not too thick. To make certain that the threads are correct all the way, run a plug tap through in the same manner.

QUESTIONS

1. **Explain what is meant by "tapping" a hole.**
2. **Name the three taps found in a set.**
3. **What is meant by the term "blind hole"?**
4. **What tap is used in tapping a "through" hole?**
5. **What precaution should be taken when starting to tap a hole?**
6. **What size of hole should be drilled for a ½" stud? ⅝"stud?**
7. **What lubricant is used for tapping holes in steel? In cast iron?**
8. **Why is it considered good practice to frequently turn the tap backwards a half-turn during the tapping procedure?**

JOB SHEET NO. 18
TO DRILL A HOLE FOR A STUD

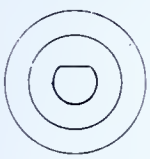


Showing a taper-shank drill with the shank larger than the drill.

Care must be taken not to apply too much pressure and snap the drill at the neck.

Two views of a taper-shank twist drill with a "flat" to prevent turning in the chuck.

Top View Of Chuck, Drill, And Sleeve



The taper sleeve is used to make up for the difference between the size of the hole in the chuck and the taper shank of a small drill.

Top views of taper shank drill

FIG. 241

General Information

Occasionally a pipefitter must drill holes for studs, bolts, etc. For example, in cases where a pipe is fastened to a bulkhead or to a tank top the flanges are sometimes used to make a watertight joint. In such a case, a large hole (the diameter of the inside of the pipe) is cut in the bulkhead or tank, and the necessary number of small holes are drilled and tapped around the large hole for the flange studs to screw into.

Drills are kept in the tool crib for the use of all workers who may require them. Since the tools are made of high-carbon or high-speed steel, they may easily be broken. The cutting edges may be chipped, or the drill may snap off if the workman is not careful to hold the drill steady while he is drilling.

Most shipyard air drilling machines have a flat side in the chuck taper. There is a corresponding flat on the tapered shank of the drill. There is little danger that this type of drill will slip in the chuck. See Fig. 241.

Safety — Always wipe the hole in the chuck and the shank of the drill with a rag or clean waste before inserting the drill in the chuck. Never allow dirt or grit to remain on these surfaces. The drill will be thrown out of line and the tapers scratched.

When removing a drill from a chuck, use a drift made for the purpose. Never strike the drill to loosen it from the chuck or sleeve.

A drift is a piece of steel tapered like a wedge. The drift thickness fits the width of the slot in the chuck spindle or tapered sleeve. The thin edge of the wedge is inserted in the slot between the end of the drill shank and the upper end of the slot. As the drift is driven in, the drill is forced down. A light blow is sufficient in most cases.

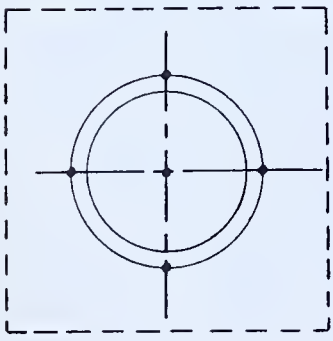


Fig. 242 — *Marking the Hole Location with a Witness Circle*

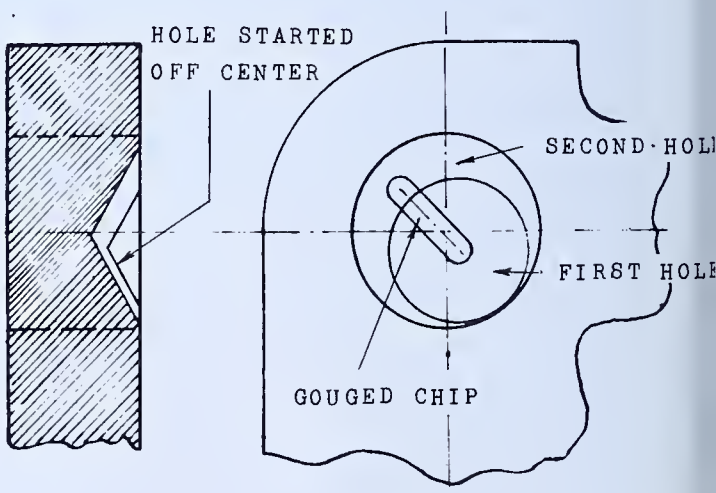


Fig. 243 — *"Drawing" the Drill to Center*

Lubrication — No lubricant is necessary for drilling cast iron. Use light lubricant for steel.

Locating a hole — All important holes should be "laid out" before they are drilled. Laying out a hole is done by center punching the exact center at the intersection of two lines. The dividers are then used to lay out the size of the hole. A "witness" circle is made around the hole circle. Punch marks should be about every ½" on large-circle circumferences. See Fig. 242. The drill may occasionally "run off". In such a case the operator will have to raise the drill from the work to inspect the cutting location before the drill has gone far enough to cut to size. If the hole shows signs of running off, a groove is chipped with a gouge chisel on the wide side of the layout. See Fig. 243. This groove will cause the drill to "bite in" each time the cutting edge hits the groove. If the drill is still off after a few more turns, chip the groove again until the drill is cutting central with the layout. The instructor will demonstrate the correct procedure.

DRILL SIZES — In choosing the correct size of drill for a hole that is to be tapped, the worker generally consults a chart or handbook. For example, the proper size of drill to use for tapping a ⅝" hole is 17/32". The following table will give a few of the tap-drill sizes:

Table No. 12

SCREW THREAD OUTSIDE DIAMETER	TAP DRILL SIZE	SCREW THREAD OUTSIDE DIAMETER	TAP DRILL SIZE
1/8	3/32	13/16	21/32
5/32	1/8	7/8	49/64
11/64	9/64	15/16	53/64
3/8	5/16	1	7/8
1/2	27/64	1- 1/8	63/64
9/16	31/64	1- 1/4	1- 7/64
5/8	17/32	1- 3/8	1- 7/32
11/16	19/32	1- 1/2	1-11/32
3/4	31/32		

NOTE: For a complete table, refer to a machinist's handbook or charts published by a drill or tap company.

PROBLEM: Lay out and drill a hole for a ½" stud.

TOOLS AND EQUIPMENT

1. Portable air drill
2. Drill socket
3. 27/64" drill
4. "Old man" or stick
5. Heavy center punch
6. Dividers
7. Small center punch

Materials

Piece of ⅝″ plate
Chalk

Work Procedure

1. Lay out on the plate and mark the center where the stud hole is to be drilled with a deep center-punch mark.

   Draw two lines perpendicular to each other as shown in Fig. 245.

2. Set the dividers for approximately one-half the size of the tapped hole, or ¼″. (Half of 27/64″ would be the correct size.)

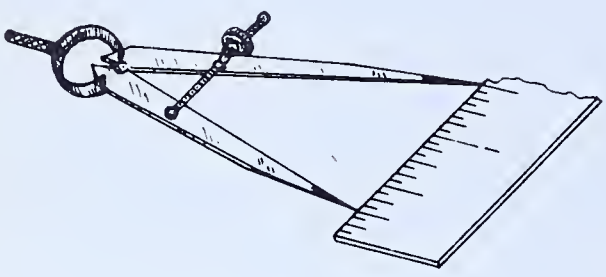


Fig. 244 — *Setting the Dividers*

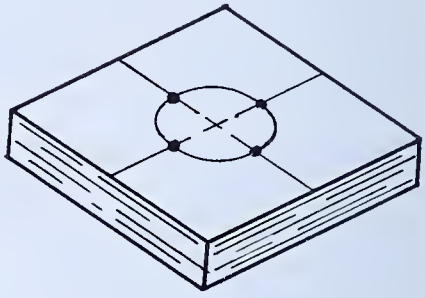


Fig. 245 — *Guide Marks (Center Punched)*

3. Place one point of the dividers in the center-punch hole, and scribe a circle.

   Chalk applied to the surface of the plate before the lines are marked will greatly aid in checking for accuracy.

4. With a center punch and a ball-peen hammer make four center-punch marks around the circle as shown in Fig. 245.

   These four marks act as a guide to let the drill operator know when the drill crawls to one side.

5. Secure the correct size of drill. The proper size in this case is 27/64″ for a ½″ tap.

   Caution: When checking out a drill for drilling holes which are to be tapped, the mechanic should be careful to get the right size for the tap. Charts of these sizes are kept in the toolroom.

6. Fasten the drilling post or "old man". Refer to Job No. 16.

   A drilling stick may be used.

7. Insert the correct size of drill in the portable drill.

8. Set the arm of the "old man" the over-all length of the motor, that is, from the end of the drill to the end of the feed-wheel shaft.

   The feed wheel should be down to the bottom of its feed length.

9. Place the end of the drill in the central center-punch mark.
10. Place the upper end of the feed-wheel shaft in the proper countersunk place on the arm of the "old man".
11. Square up the drill, motor, and "old man" so that they are perpendicular to the work.
12. Adjust the feed wheel until there is a slight pressure on the motor and drill.
13. Oil the drill.
14. Start the motor.

    Watch the drill closely to see that it runs true and drills straight.
15. Feed the motor slowly.

    Turn the feed wheel about a half-turn at a time. Lubricate the cutting edge of the drill. Keep a good grip on the motor handles at all times. Should a drill freeze or stall in the hole, turn off the power at once. Slack off the feed on the wheel and start the motor again.
16. Drill the hole through.

    When a hole is drilled through, a large bite is sometimes taken and it may stall the motor. If this happens, shut off the motor.
17. Remove the "old man".
18. Lift the motor and hold it up so that the drill is up clear of the hole.
19. Start the motor and gradually lower the drill into the hole.
    NOTE: This procedure is to clean up the bottom edge, which sometimes is rough or unfinished because the drill makes an extra heavy bite.

QUESTIONS

1. **Explain the use of the central center-punch mark.**
2. **Why are other center-punch marks placed around the circumference line?**
3. **What size of drill is used for a ½″ tap?**
4. **Where on the drill can the size be found?**
5. **What should be done when the drill stalls in the work?**
6. **What generally causes the drill to stall or freeze in the work?**
7. **What is meant by the "crawling" of the drill?**
8. **Explain how a hole may be straightened after the drill has been found to be crawling?**

JOB SHEET NO. 19
TO USE AN "EASY-OUT"

General Information

Marine pipefitters are occasionally confronted with the problem of removing a stud or a broken bolt. Such a task is sometimes very difficult to do. Often the threads are rusted, and the stud or bolt may break under the strain of turning it out of the threaded hole. If the broken portion remaining in the tapped hole projects far enough, a pipe wrench may be used and the broken piece backed out. If the wrench cannot be used, nuts may be locked on the threaded end of the stud which projects from the work, and the stud may be backed out. This, of course, is only possible where there is enough thread left on the free end.

Where a stud has been broken off flush with a casting and there is no way of placing a wrench or backing-out stud nut on the stud to screw it out, it must be drilled out or drilled so that it may be removed with a tool called an "easy-out". After the stud or broken bolt had been removed, the hole should be tapped to insure a clean thread.

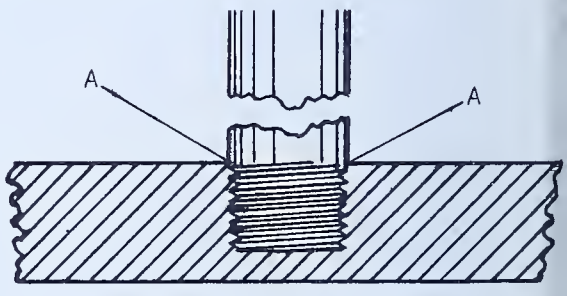


Fig. 246 — *Broken Stud*

When a stud has been broken off above the surface of the work as shown in Fig. 246, saw or chip off the projecting piece flush with the surface of the work at point *A*. File the stud as smooth as possible. When the surface of the broken stud has been smoothed, put prick-punch marks on the circumference of the stud as shown in Fig. 247, points *a*, *a*, *a*, and *a*.

One point of the dividers is placed in the prick-punch mark *a*, and with the other an arc is scribed as close to the center of the broken stud as possible. The arc is scribed by taking half the diameter of the hole for the radius of the arc. This procedure is repeated from other points *a*.

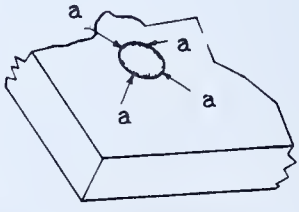


Fig. 247 — *Prick-punch Marks on Circumference of Stud*

Where these lines cross in the center, a mark is made with a center punch, as shown in Fig. 248.

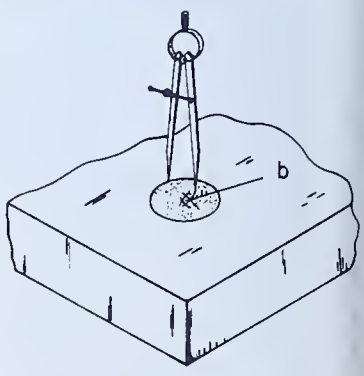


Fig. 248 — *Finding the Center of the Stud*

Tools and Equipment

1. Air drill
2. Dividers
3. Prick punch
4. Center punch
5. Drill
6. "Easy-out"
7. Tap wrench
8. File
9. Hammer
10. Gouge chisel
11. Drift key
12. Set of taps
13. Screw pitch gauge

Materials

Material in which stud has been broken
Chalk

Work Procedure: (Using an "easy-out")

1. Smooth off broken stud even with surface of job.

   A chisel or hack saw may be used. In most cases a file will do the required job. See Fig. 247.

2. Chalk over the stud.

3. Locate the center of the stud with dividers.

   To do this, make four prick-punch marks at equal intervals on the circumference. Place one divider point in *a*, Fig. 247, and with the other scribe an arc in the center of broken stud. Repeat this procedure, using the other prick-punch marks.

4. Mark the center with a center punch. See Fig. 248 at *b*.

   Mark is made where all the scribed lines cross in the center of the stud.

5. Drill a through hole on this mark.

   The size of the drill should be approximately two thirds of the diameter of the stud.

   For example: For a ½″ stud, drill a 5/16″ hole.

6. Select an "easy-out" of the proper size. See Fig. 249.

7. Drive the "easy-out" snugly into the drilled hole.

8. Back the broken piece of stud out of the hole, using a close-fitting wrench on the square of the "easy-out".

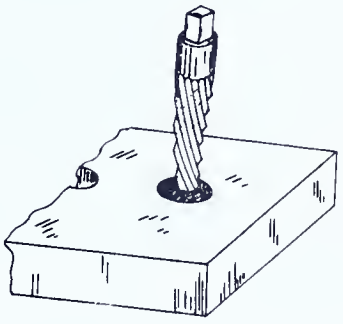


Fig. 249 — *Using the "Easy-Out" (Stud Extractor)*

Work Procedures (Drilling the broken stud and re-tapping)

1. Locate center of the stud with dividers as in Step 1 of foregoing work procedures.

2. Select a drill about 1/32″ smaller than the root of the thread of the broken-off stud.

   This is to prevent ruining the threads in the casting.

3. Place the drill in the air-motor drill socket.

4. Fasten drilling post over the broken stud, and place the drill in the motor, central with the center-punch mark in the stud.

5. Remove stud shell.

   Split the shell with a sharp gouge chisel. Tap the gouge point against the shell lightly with a hammer until the shell is removed from the hole.

6. Secure a tap the same size and number of threads as the removed stud. (Use screw pitch gauge.)

7. Re-tap the hole by hand.

   This will remove the burrs made with the gouge chisel.

QUESTIONS

1. **Explain some of the methods used to remove broken studs or bolts.**

2. **Why is it important to start the drill in the center of a broken stud?**

3. **Why are prick-punch marks put on the circumference of the stud?**

4. **Why is the drill used in drilling out a broken stud, smaller than the stud?**

5. **How does the mechanic determine the size of the drill for drilling a hole in a stud that he plans to remove with an "easy-out"?**

JOB SHEET NO. 20
* TO MAKE A MITER WELD JOINT

General Information

It is often necessary, aboard ship, to install a section of pipe line similar to the part shown in Fig. 250.

To make a short bend in the pipe as shown by the dotted lines at *A* in Fig. 250, it is necessary to fill and pack the pipe with sand, plug the ends, and heat it. When

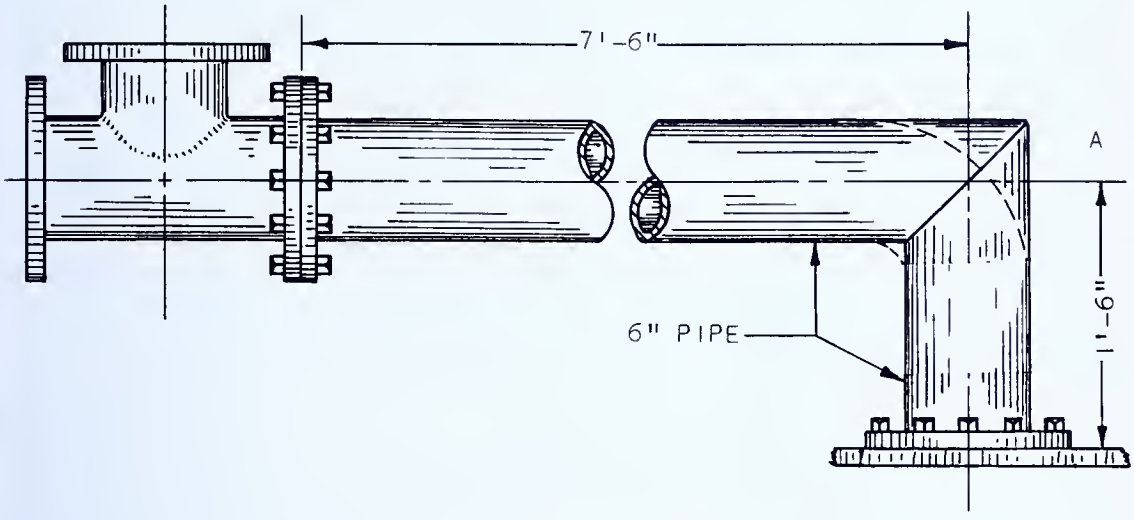


Fig. 250 — *Part of a Pipe Line Aboard Ship*

properly heated, it is bent on a face plate to the correct radius. This process is slow, and many times the pipe will stretch too thin on the outside of the bend or it will buckle on the inside of the bend.

To overcome these difficulties, the pipefitter cuts the pipe on a miter (a miter always produces a 90° bend, but similar angle cuts, 45°, 22½°, etc. are often called miters) and welds it. Since a miter joint is just as strong and will hold just as much pressure as its equivalent in a bent piece, it is often used for economical reasons. Where the sharp angles of mitered pipe will not cause obstructions to the flow within the pipe, there is no objection to its use.

Tools and Equipment

1. Combination square
2. Ball-peen hammer
3. Center punch
4. Soapstone
5. Steel tape
6. Acetylene burning torch
7. Batten wood at least 7′ 6″ long

*Adapted from "Marine Pipefitting", by State Department of Education, Alabama.

Materials

6″ pipe, 8½′ long (same procedure for black, galvanized standard, or extra-heavy).

Two 6″ standard-steel slip flanges

Procedure

1. Measure with the steel tape and make a center-punch mark on the pipe 7′ 5¾″ from one end, as shown at *a* in Fig 251.

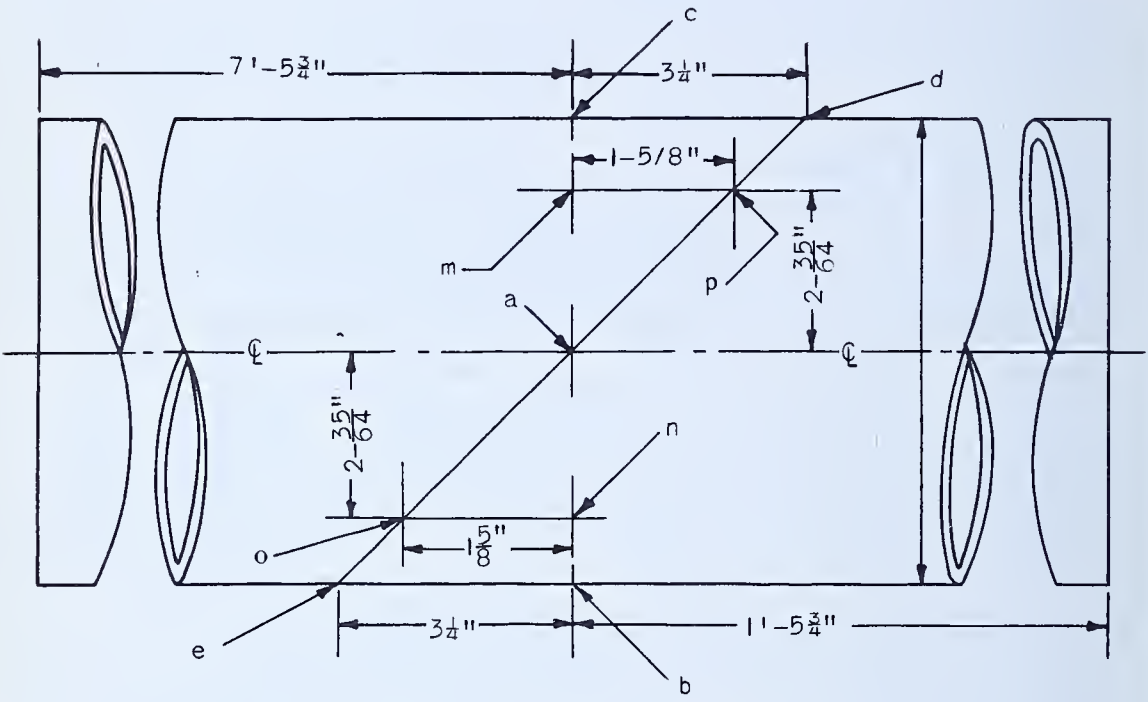


Fig. 251 — *Laying Out a Miter Joint*

2. Strike a line (using a piece of batten wood with a straight edge) straight down the pipe to pass through the center-punch mark at *a* in Fig. 251.
3. Find the circumference of the 6″ pipe.
   Circumference = Diameter x pi
   For the sake of clarity it is assumed that the
   Outside Diameter of 6″ pipe is 6½″
   6½ = 6.5; 6.5″ × 3.1416 = 20.42″, or 20 7/16″ approximately.
4. Divide the circumference by 4
   20.42 ÷ 4 = 5.105″, or 5 3/32″ approximately.
5. Measure 5 3/32″ around the pipe from the center-punch mark in both directions, and mark the distances with soapstone. See Fig. 252 at points *b* and *c*.
6. With the tape, measure from the end of the pipe and check the soapstone marks

b and *c* to determine if they are 7′ 5¾″ from the end, the same as center-punch mark *a*. If the distance is the same, make center-punch marks at *b* and *c*.

7. Make center-punch marks at *e* and *d* as shown in Fig. 251.

The O.D. of the pipe is 6½″. To make a 45° cut on the pipe, one half of the O.D. is marked at *d* and the other half of the O.D. is marked at *e*. Measure

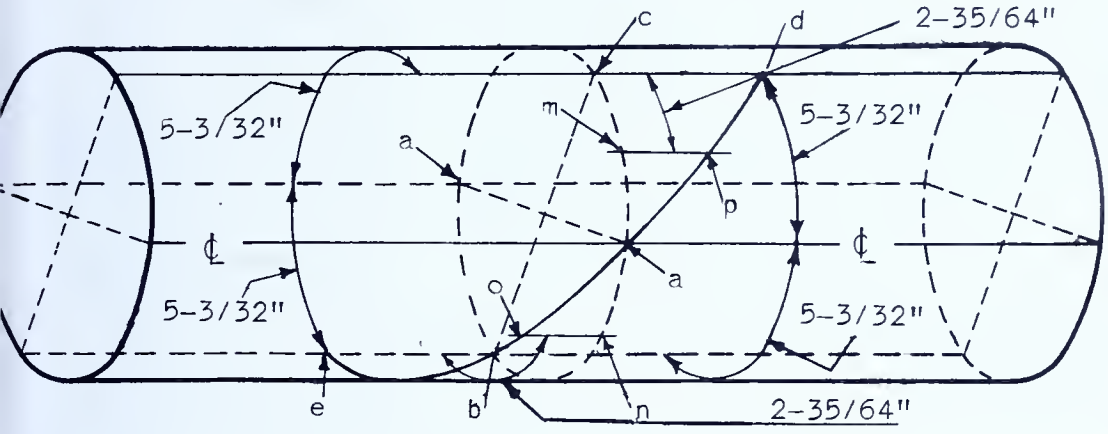


FIG. 252 — *Measuring to Locate Center-Punch Marks*

from *c* to get point *d;* measure from *b* to get point *e*. Points *d* and *e* must be 5 3/32″ from the center line, measured around the circumference of the pipe, as shown in Fig. 252.

8. With the tape, measure from the end of the pipe 7′ 5¾″ and mark with soapstone points *m* and *n*, Fig. 251.

Make short marks at right angles to the center line of the pipe about half way between center-punch marks *a* and *b*, and *a* and *c*.

9. Find the locations of points *o* and *p*.

Measure from marks *m* and *n* 1 ⅝″ to short lines as shown in Fig. 251, and make short lines with soapstone. Measure from the pipe center line 2 3/64″, and with soapstone mark the intersections at *o* and *p*.

10. Check the locations of these points carefully; if they are correct, make center-punch marks at the intersections.

11. Repeat Steps 8 through 10 on the opposite sides of the pipe.

12. Strike a soapstone line from point *d* to *e* cutting through points *p*, *a*, and *o*.

13. Repeat on the opposite side of the pipe.

14. Mark the lines from *d* to *e* with the center punch at 2″ intervals on both sides of the pipe.

15. Have the pipe burned through on the line marked with the center punch.

16. Check with the combination square to make sure that the miter is a true 90° angle.

17. Invert the piece that was burned off and have the joint tack welded. See Fig. 250 and Fig. 253.

18. Place the slip flanges on the ends of the pipe and bolt them in place.
The measurement of the pipe length, 7′ 5¾″ + 1′ 5¾″ = 8′ 11½″, which is ½″ shorter than the total length of the pipe shown in Fig. 250. The ¼″ short on each end allows for a welding bead which seals the joint on the inside of the slip flange. A shoulder weld is made on the outside. If any of the original length was lost in the burning of the pipe, it is made up in the sealing bead, Fig. 253.

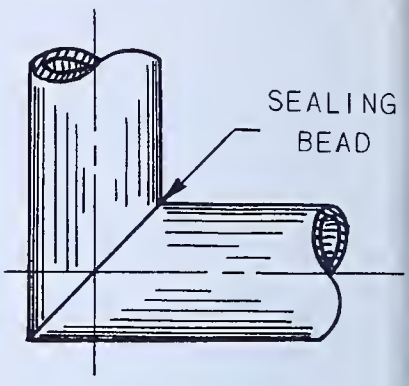


FIG. 253 — *Welded Miter Joint*

19. Sight the alignment of the pipe carefully, and tack weld the flanges.

20. Re-check the alignment; if it is correct, remove the pipe.

21. Have the welder complete the welding job.

22. Bolt the pipe into position.

QUESTIONS

1. **When is it more practical to miter pipe than to use a bend?**
2. **Explain how the diameter of the pipe is used in laying off a miter for a 45° angle.**
3. **What is the purpose of tack welding the miter?**
4. **Figure the circumference of a pipe 4½″ O.D.**
5. **State from what base points the measurements of the pipe layout are taken.**
6. **How is the cutting line marked on the pipe?**
7. **Why is particular care taken to have the cutting lines on opposite sides of the pipe register exactly with each other?**
8. **When is the miter joint ready for welding?**

JOB SHEET NO. 21
TO TEST A PIPING ASSEMBLY

General Information

All piping installations must be tested according to specifications before they may be considered as complete. On some jobs the tests are conducted in the pipe shop before they are installed. Here the section is assmbled as it would be aboard ship and is subjected either to an air-pressure or a water-pressure test. Leaking joints or poor welds are disclosed and the necessary repairs can easily be made. The test pressures are usually at least twice as great as the actual pressures the piping will have to withstand in actual service.

The piping assemblies that cannot be tested in the shop have to be tested aboard ship. In this case the test pump must be carried aboard ship. It is essential that all piping is thoroughly tested before the ship is put into service. Leaks in certain lines might result in disastrous accidents. Leaks in other lines might partially destroy the cargo.

When the air test is used, soapy water must be brushed over all joints and connections. Leaks are detected by the formation of bubbles. High pressure steam lines are subject to a great deal of wear. Bends and elbows receive most of this wear and for this reason provision must be made for checking the wall thickness on the outside of bends.

The pipefitter drills and taps a hole in the outside of a bend. A plug 6″ long is screwed into the hole. This 6″ plug will extend through the pipe covering after it is installed and can easily be detected by the inspector. Specifications call for a certain percentage of the maximum wall thickness on all bends. The inspector can remove the plug and test the wall thickness in the bend through the hole by means of a special micrometer.

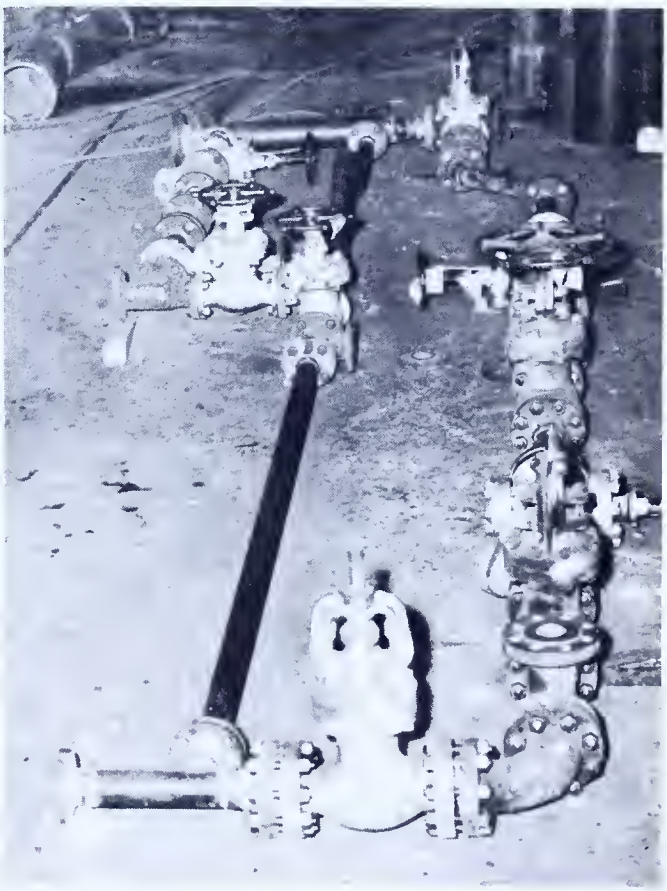


FIG. 254 — *Testing Pipe Assembly in the Shop*

PROBLEM: To test the auxiliary steam piping assembly shown in Fig. 254.

TOOLS AND MATERIALS

1. Hydrostatic test-pump.
2. Piping assembly
3. ½″, ⅝″, ¾″, 1″, open-end wrenches

PROCEDURE

1. Connect the feed line from the pump to the open end of the assembly.
2. Check over all connections to see that they are tight.
3. Open all valves.
4. Start the pump.
5. Continue pumping until the gauge registers the required amount of pressure.
6. Examine each joint and connection for leaks.
7. Hold this pressure long enough to check all joints for possible leaks.
8. If any leaks are observed release the pressure and make the necessary repairs.
9. After repairs are made, again subject the line to the test pressure. Have inspector check assembly and approve it.
10. If no leaks are observed disconnect the test pump line.

QUESTIONS

1. **Why is piping tested in the shop?**
2. **Explain the two common methods of testing pipe.**
3. **Who checks over a pipe assembly that is being tested?**
4. **Should pipes ever be tested aboard ship? Why?**
5. **What piping system receives the greatest test pressure?**

JOB SHEET NO. 22
TO INSTALL RAILING STANCHIONS AND RAILING

General Information

Railing is provided on all steps and grating where danger from falling is present. Much of the railing is installed in the engine room and inner parts of the ship. All outside walks are protected by railings. The rolling and pitching of the boat would make walking almost impossible without the aid of railings. The locations of railings and stanchions are specified on blueprints.

Several different types of railings are used on a ship. The type depends upon the location and the use of the railing. Stanchions are of the overhead type or of the upright type. They may be welded fast or bolted or pinned into a socket. The type of stanchion and foot depends upon the available fastening location.

Railings around the bridge or wheelhouse are made of brass to prevent any compass deviation. Stanchions on or along the steel deck are usually welded to the deck or shell. Some stairways in the engine room have to be made as temporary installations because they may have to be removed to repair machinery. One stairway on certain boats goes by the cleanout door on a boiler. If the boiler must be cleaned, the stairway must be removed in order to open the cleanout door. For installations of this type, stanchions are bolted or pinned in place. (Fig. 255)

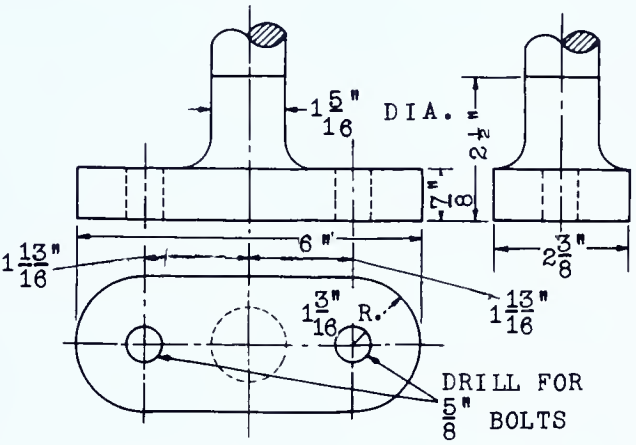


Fig. 255 — *Bolt-on Type of Stanchion*

Stanchions are always fastened perpendicular to the surface to which they are attached. On stairs, the stanchions form a right angle with the slope of the stairs. The spacing of the stanchions depends upon the location of the railing and also upon the available fastening place.

All material needed for installing railings will be listed on a blueprint covering railing installations in a certain section of a ship. Such things as the size and length of pipe, the number of bolts, number of fittings, etc., are all listed on a bill of materials on the blueprint. The mechanic must refer to the print frequently in order to properly install railing. Location of railing and dimensions for fastening stanchions must be obtained by scaling the print.

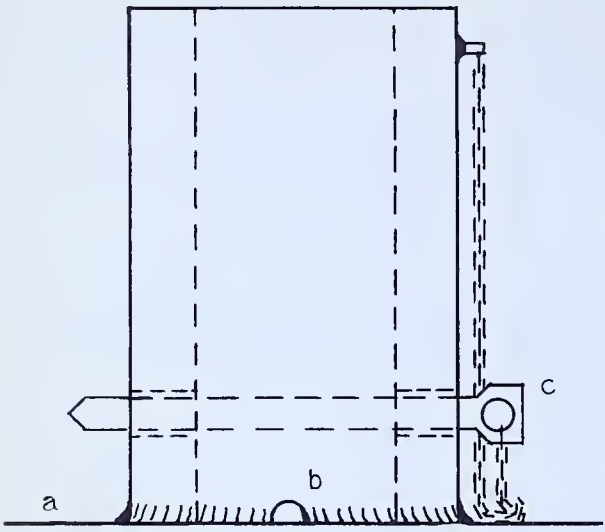


FIG. 256 — *Welded Socket Type of Stanchion Support*

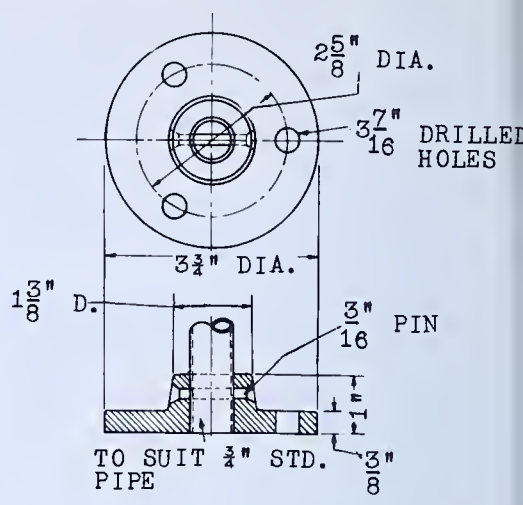


FIG. 257 — *Bolted Socket Type of Stanchion Support*

Temporary deck railings are usually fastened in the manner shown by Fig. 256. A short piece of 2½″ double extra-heavy pipe is drilled or bored out so that a stanchion will fit snugly in the bore. This piece is welded on the deck plate *a*. An opening *b* is left in the bottom for draining water that may get into the socket. The stanchion on the railing is slipped into the socket and a hole for the locking pin is drilled through the socket and the stanchion. The pin *c* is fastened to a short chain which in turn is welded to the socket so that it will not be lost. Deck railings are usually made with two rails. The ends of pipe are always located in the ball in the stanchions. These pipe ends are welded to the stanchions.

A length of rail starts in a stanchion, is welded there, and may pass through one or two other stanchions but is welded again only to the stanchion where it ends.

After a line of railing has been installed it may have to be aligned. Some of the stanchions may be out of line. If a stanchion is seen to be out of line, a welder heats the foot so that the stanchion can be straightened.

Sometimes in engine-room railing a length of rod may not be long enough to reach the end. If a case like this is encountered a tapered sleeve is used to butt two pieces of rod together. The tapered sleeve is fitted on one end of rod so that the rod extends halfway through the sleeve. (Fig. 258). A hole is drilled through the sleeve and the rail, for a pin that will bind the rail to the sleeve. The other piece of rail is slipped into the tapered sleeve tightly against the end of the rail. This end is then drilled and pinned into place. The ends of the pins must be filed even with the outside of the sleeve.

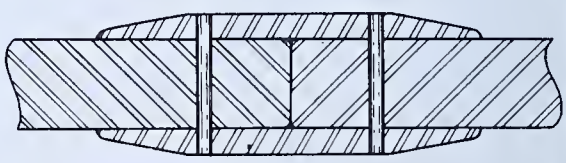


FIG. 258 — *Tapered Sleeve Railing Joint*

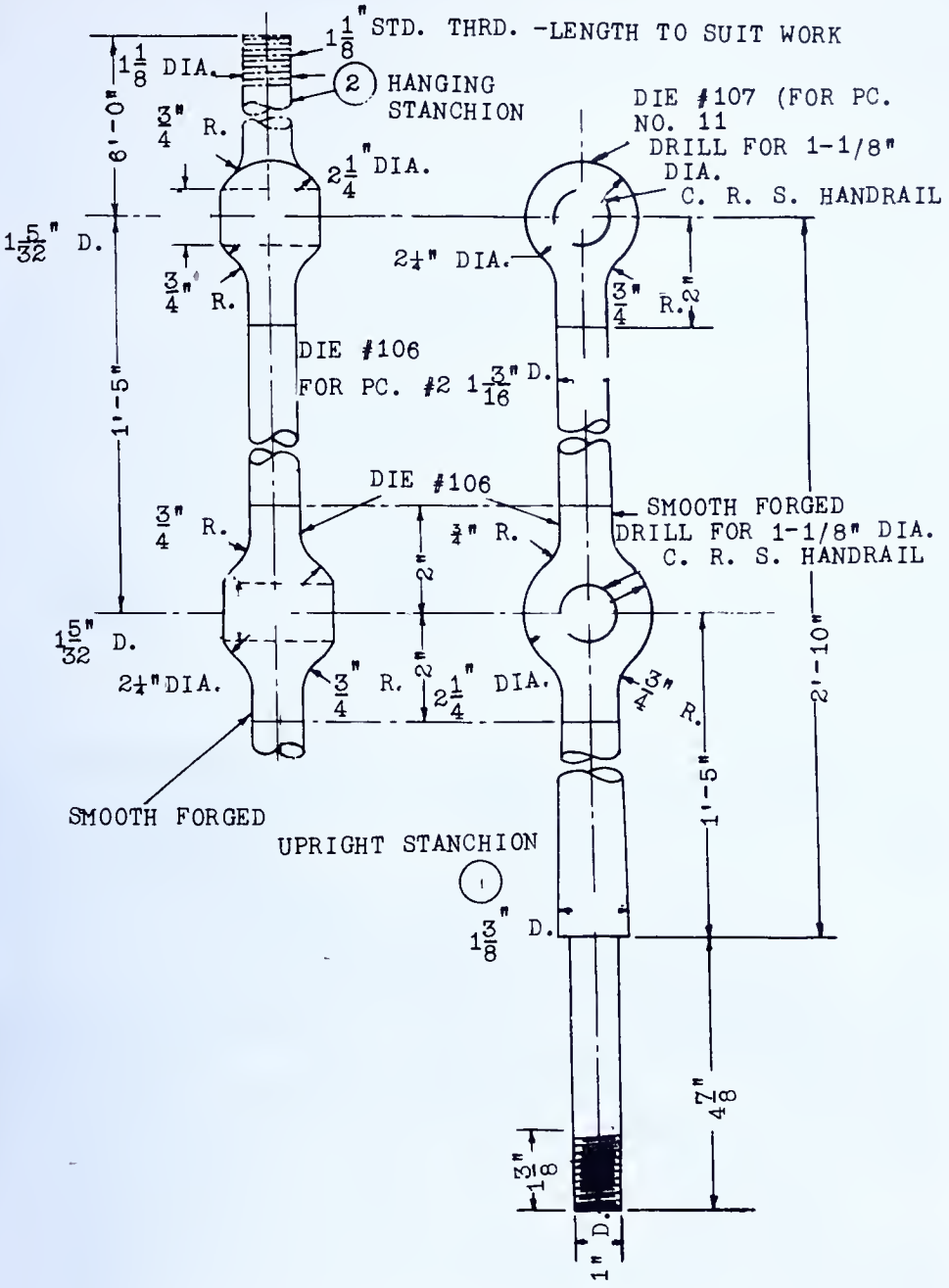


FIG. 259 — *Typical Engine Room Stanchion*

Railings that have to be fastened to grating, use a foot similar to the one shown in Fig. 260. A great deal of grating is used in the engine room to form the various levels for working around the machinery and pumps. A stanchion foot like the one illustrated here is easily clamped to the heavy bar of the grating. Two clips fit over the bar. The threaded stanchion end (Fig. 260) goes through the holes in the clips. When a nut is turned tightly on the stanchion the two clips securely grip the grating

and form a solid support. One advantage of using fasteners of this type is that they can be quickly and easily removed.

PROBLEM:

To install a typical railing in the engine room.

TOOLS AND EQUIPMENT

1. ½", ⅝", ¾" open end wrenches
2. Ball-peen hammer
3. Center punch
4. Cold-rolled steel bar
5. Chisel
6. Hacksaw
7. File
8. Stanchions and stanchion feet

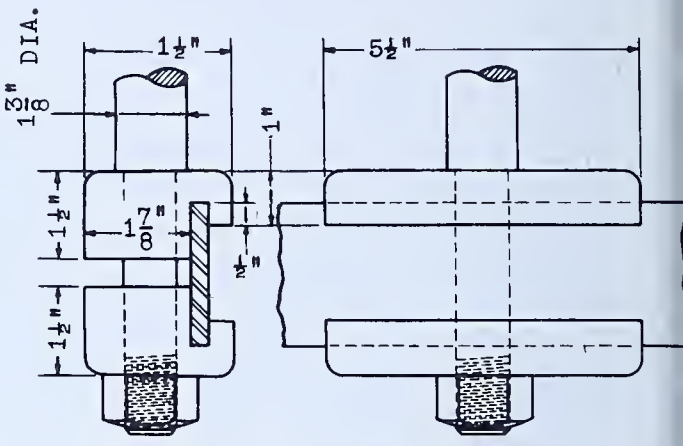


FIG. 260 — *Grating Clip Stanchion Support*

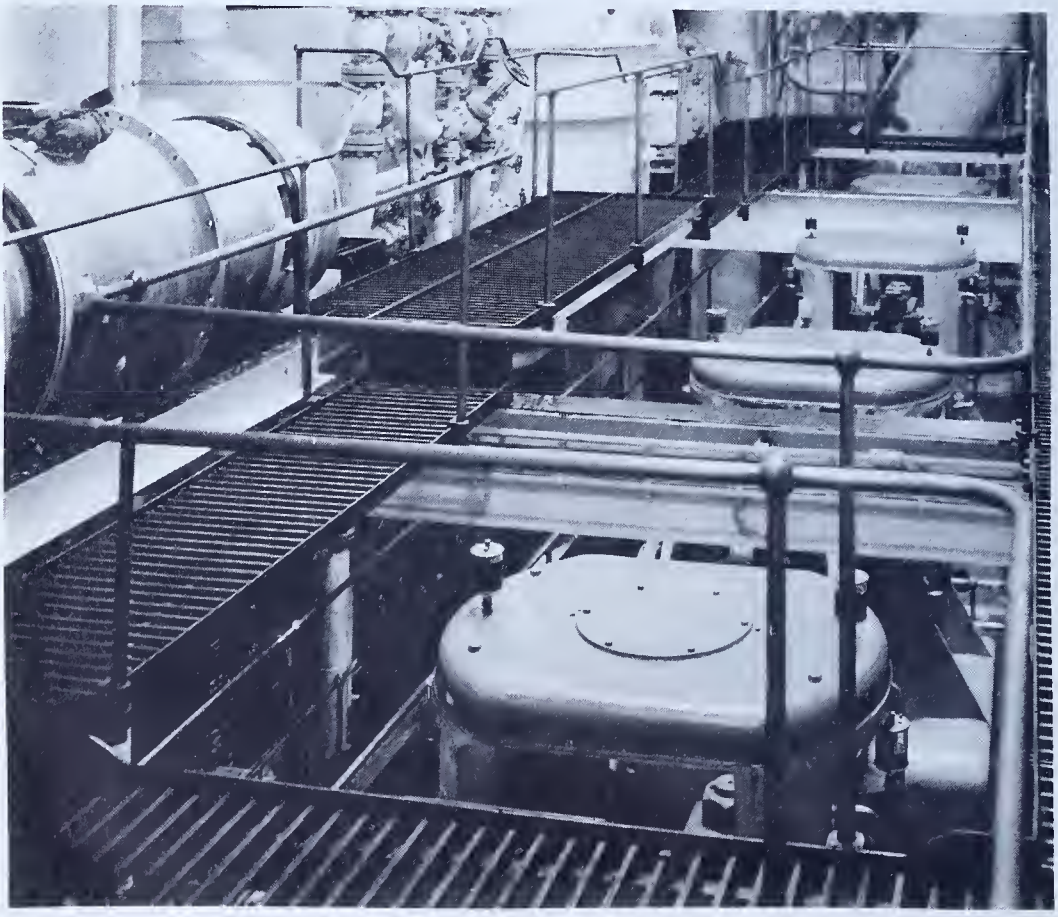


FIG. 261 — *Typical Engine Room Railing*

PROCEDURE

1. Obtain the proper blueprint and check conditions on board the ship with the drawing.
2. Obtain a sufficient amount of template rod and bend the rod to conform to the required bends of the railing.
3. Measure the job to find out how much railing will be needed.
4. Obtain the necessary amount of railing and the stanchions and stanchion fasteners that will be needed.
5. Make the first bend and slide the required number of stanchions on the railing.

   The number of stanchions between bends will be obtained from the blueprint. These stanchions must be slid over the straight end of pipe. The burr on the end of the rod may have to be filed off in order to slide the stanchion on the rod. They cannot be slid over bends because the openings through the stanchions are very nearly the size of the railing. The bends in the railing are made on the air bending machine. The radius of the bends varies with conditions. It may not be too abrupt or too long. The bend should present a smooth streamline appearance.
6. Proceed to make the next bend and slide stanchions over the straight end.
7. Continue the bending and sliding on of stanchions until the railing assembly is completed.
8. Take the railing assembly to the ship and proceed to install the assembly.
9. Check with the drawing and mark the locations of the stanchion feet.
10. If the feet are bolted in place, center punch the locations of the necessary holes. Have the holes drilled.

    If the feet are to be welded fast, hold the stanchions in place and have the feet welded.
11. After the holes are drilled, proceed to bolt the railing and stanchions in place.

QUESTIONS

1. **Explain why railings are installed on a ship.**
2. **How or with what, are railings secured?**
3. **Why are some stanchions pinned or bolted fast while others are welded to the ship?**
4. **How does the pipefitter know where stanchions are to be placed?**
5. **Of what materials are railings made?**
6. **Why should stanchions never be welded in place before the railing has been inserted?**

JOB SHEET NO. 23
TO SCALE PIPING BLUEPRINTS

Drawings from which blueprints are made cannot possibly be drawn to the same size as the parts or installations they explain. Only very small parts or tools are shown in actual size on blueprints. On machine drawings or die drawings enough dimensions are given on the drawing to enable the mechanic to make the parts. On piping installations, however, very few dimensions are given. Usually, rough stock sizes are listed on one side of the print, but dimensions for locating bends or fittings are not given. In order to obtain these dimensions, for performing a certain job, the print must be scaled. That is, a scale corresponding to the one used by the draftsman is used to measure the necessary distances on the print.

Three styles of architects scales are used to scale blueprints, the flat type, the triangular type, and the folding type. The triangular scale contains the greatest variety of scales; the table below lists the various scales found on the triangular scale.

1″	= 0′-1″	⅜″	= 1′-0″
3″	= 1′-0″	¼″	= 1′-0″
1½″	= 1′-0″	3/16″	= 1′-0″
1″	= 1′-0″	⅛″	= 1′-0″
¾″	= 1′-0″	3/32″	= 1′-0″
½″	= 1′-0″		

For pipefitting work the 2′ folding architects scale will be the more satisfactory scale to use. Usually piping diagrams and sketches are drawn to a scale of one half inch to the foot; ½″ = 1′-0″. This means that every ½″ on the drawing represents one foot on the piping system itself. If a mechanic wants to find the distance from one end of a pipe to a branch or fitting, he places the ½″ scale alongside the pipe in question and reads the actual dimension from the scale. See Figs. 262 and 263.

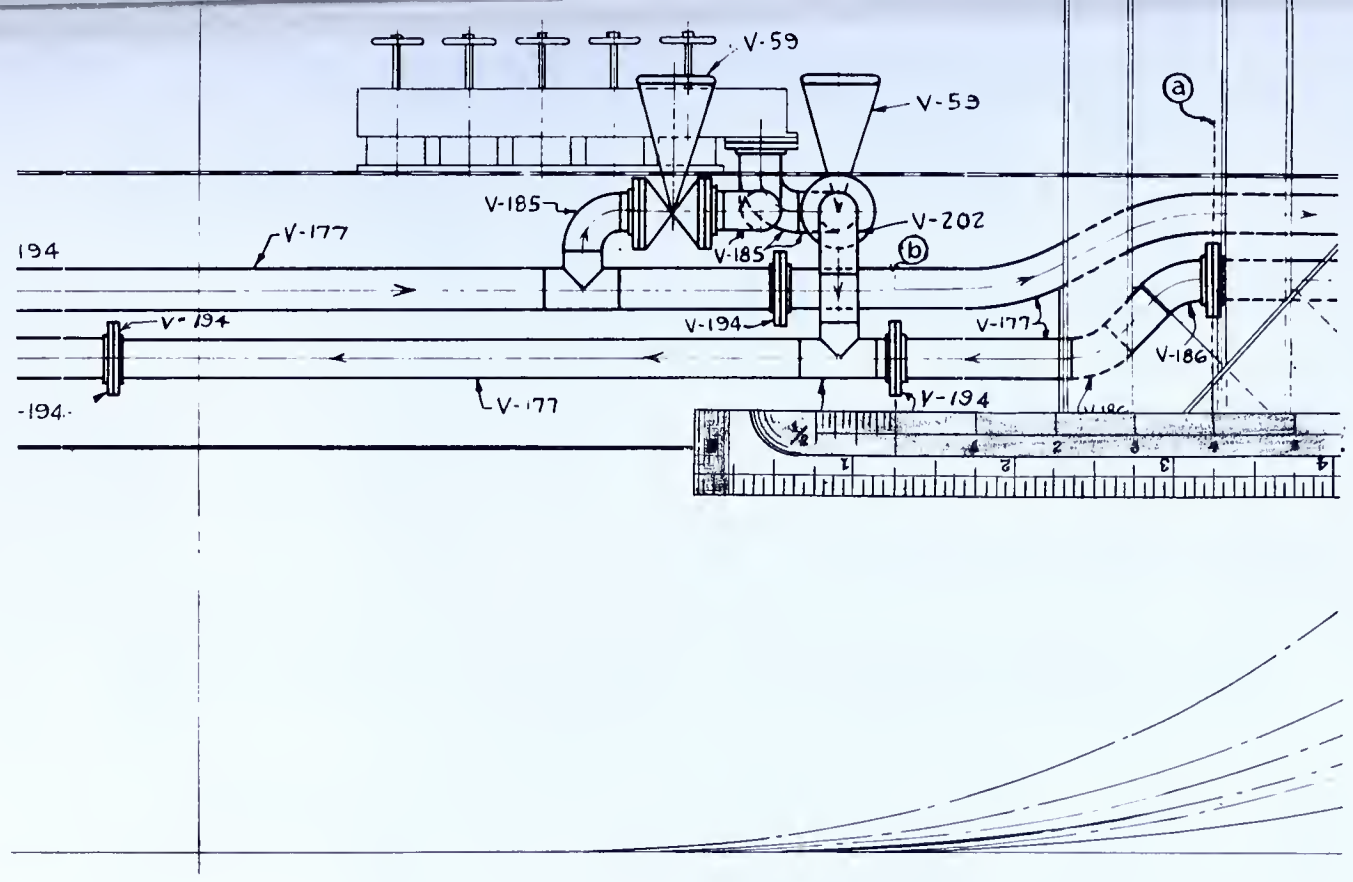


FIG. 262 — *The blueprint is drawn to a scale of* ½″ = 1′-0″ *and the measurement between flange faces* a *and* b *of an offset is being measured. The scale (two foot folding) shows the measurement to be exactly* 4′.

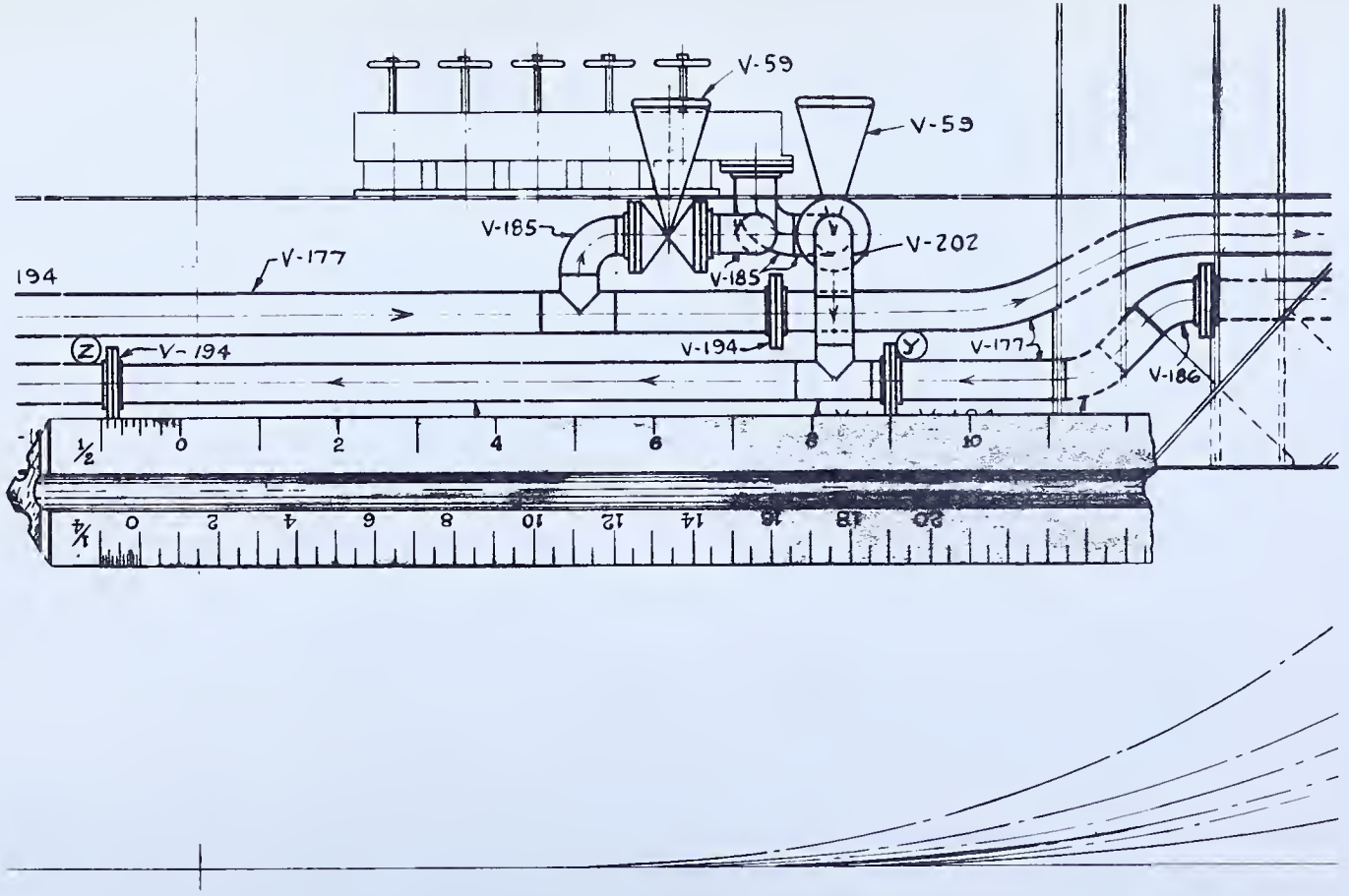


FIG. 263 — *The blueprint is drawn to a scale of ½" = 1'-0" and the measurement between the two flange faces y and z is to be found. The triangular architects scale shows the measurement to be 9'-10¼". The ¼" is obtained*

PART VI
MACHINE OPERATIONS

MACHINE OPERATION NO. 1
STATIONARY GRINDER

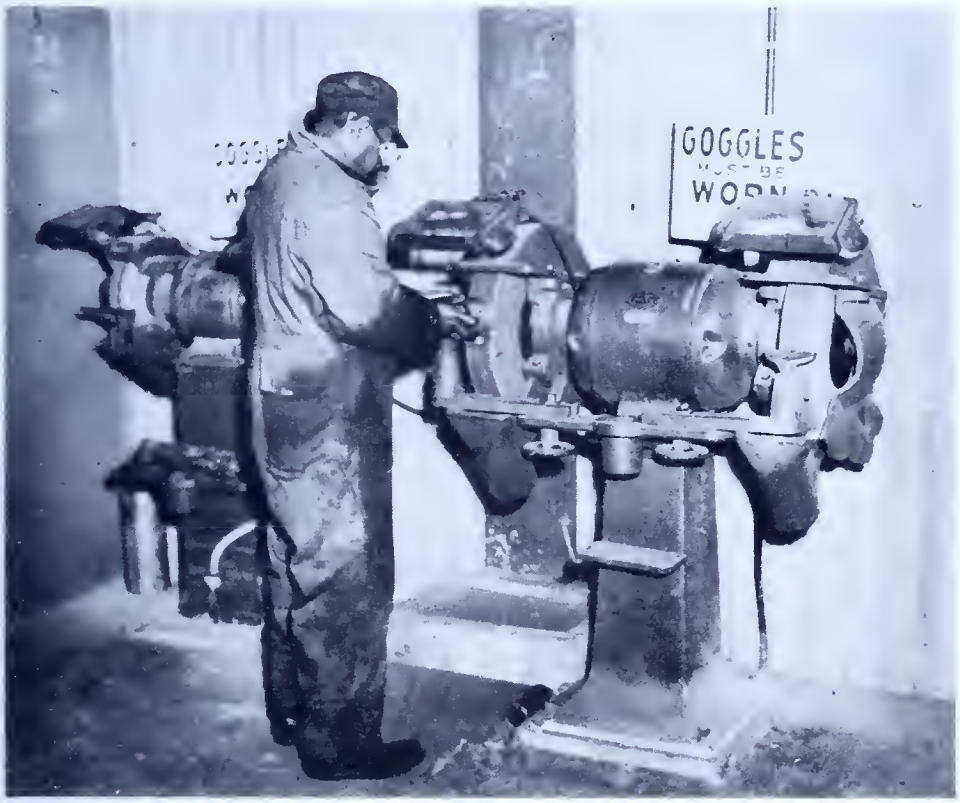


FIG. 264 — *Grinding a Short Pipe*

GENERAL INFORMATION

This type of grinder mounts two grinding wheels, one on each side of the driving motor. Usually in machines of this type one wheel is coarse-grained for roughing operations, and the other is fine-grained for finishing or smooth grinding. A safety guard covers the entire wheel except the front. An additional transparent guard protects the operator from flying sparks. Rests are provided in front of the wheels for resting the work upon while the material is being ground.

These grinders are used to sharpen tools, grind welding bevels, and to smooth and polish all kinds of metal. Care must be taken to use the coarse wheel for grinding soft metals, such as brass or aluminum. A fine-grained wheel will clog up rapidly with these metals. When tools are sharpened on the grinder, the grinding must be done a little at a time; otherwise friction will generate enough heat to destroy the temper of the tool. In the interest of safety, grinder operators should always wear goggles.

Procedure for Grinding a Bevel on the End of a Piece of Pipe

1. Examine the wheels to see which one would be most satisfactory for the job. For rough grinding a welding bevel, the coarse wheel should be used.
2. Start the motor.
3. Put on a pair of goggles.
4. Stand directly in front of the wheel and place the end of the pipe on the tool rest.
5. Tilt the pipe so that the proper bevel will be cut.
6. Push the pipe against the wheel with a light pressure.
7. Keep the pipe from rolling off the rest with one hand, while turning the pipe slowly with the other.

   While the pipe is being ground, the angle at which the pipe is held on the rest should remain the same. This will give a uniform bevel on the pipe end.

QUESTIONS

1. **What safety precaution must be observed when operating a grinder?**
2. **Why are some wheels fine and others coarse?**
3. **Why should care be taken when sharpening a tool?**
4. **How can tools be cooled when they are being ground?**

MACHINE OPERATION NO. 2
PORTABLE GRINDER

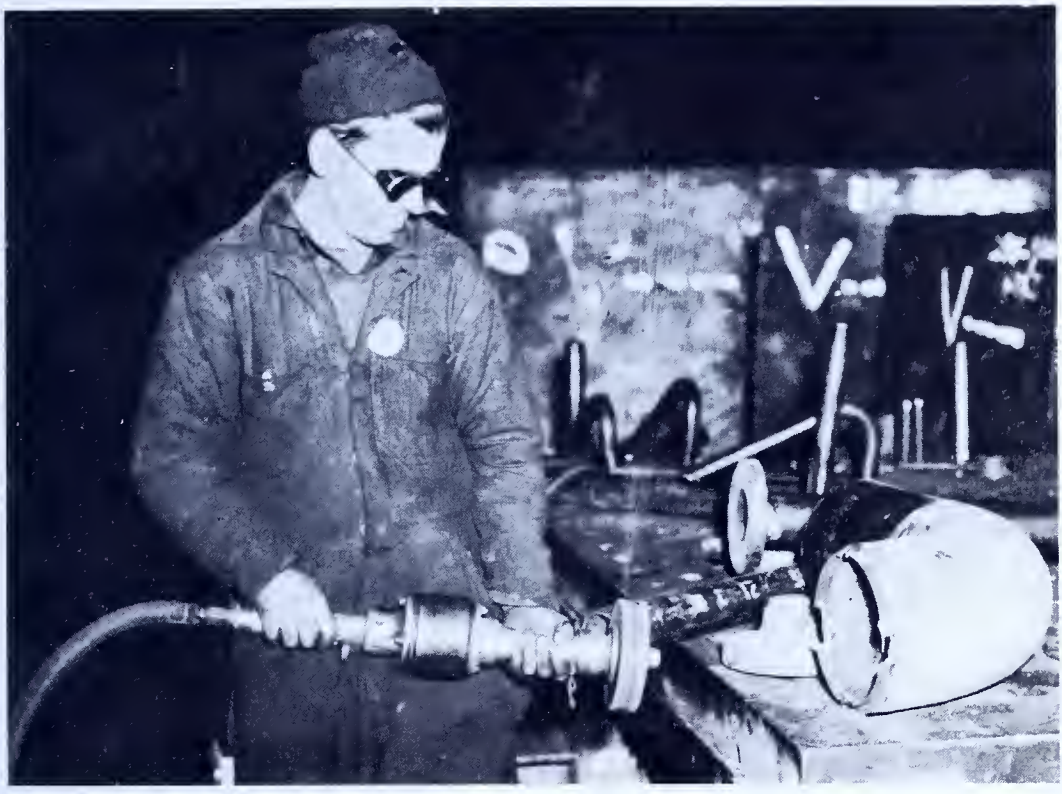


FIG. 265 — *Operating a Portable Grinder*

GENERAL INFORMATION

This small machine has a variety of uses in the pipe shop. The illustration shows the proper position in which to hold the grinder while it is being operated. The machine must be held firmly in both hands, and the operator must be standing solidly. Grinding wheels of various grades are used. Wheels range in size from 6″ to 8″ in diameter and from 1¼″ to 1½″ in width. A compressed air motor drives the wheel.

In the pipe shop, the most frequent job for this machine is cutting bevels on pipe ends that are to be welded. Rough edges may be smoothed down, and bulky welds may be ground flat. In the hands of an experienced operator this machine prepares smooth, even surfaces.

To operate the grinder, the pipefitter presses a small valve located on the back of the motor. While grinding, the operator must take care to apply proper pressure on the wheel. If the machine is held against the work too tightly, the wheel will not cut smoothly and efficiently, but will choke and lose its cutting qualities. If soft metals are to be cut, a coarse grit wheel should be used; for hard metals, a fine grit wheel will be more efficient.

PROCEDURE FOR BEVELING A PIECE OF PIPE

1. Fasten the piece of pipe on a table with the end to be beveled projecting over the edge of the table. See Fig. 265.
2. Check over the grinder to see that it operates efficiently.
   See that the correct grinding wheel is used.
3. Check over hose connections and guard to see that they are secure.
4. Stand firmly on both feet with the left side toward the work. See Fig. 265.
5. Grasp the grinder firmly with the left hand holding the wheel-end of the grinder, and with the right hand holding the hose-end grip just back of the control trigger.
6. Push the trigger to the "on" position.
7. Grind the opposite edge of the bevel first, using a swinging motion.
8. Stand facing the pipe and grind a bevel on the top and bottom edges, again using a swinging motion.
9. Stand with the right side toward the work and reverse the grip on the grinder. The left hand now operates the control trigger.
10. Grind the bevel on the opposite side, making the bevel as even as possible.

QUESTIONS

1. **Why are several grades of wheels obtainable?**
2. **What kind of wheel is used to cut steel?**
3. **What type of wheel should be used to cut brass?**
4. **What safety precaution must be observed while operating the portable grinder?**
5. **Why should the end of the pipe overhang the edge of the table to which it is fastened?**

MACHINE OPERATION NO. 3
RADIAL CUT-OFF MACHINE

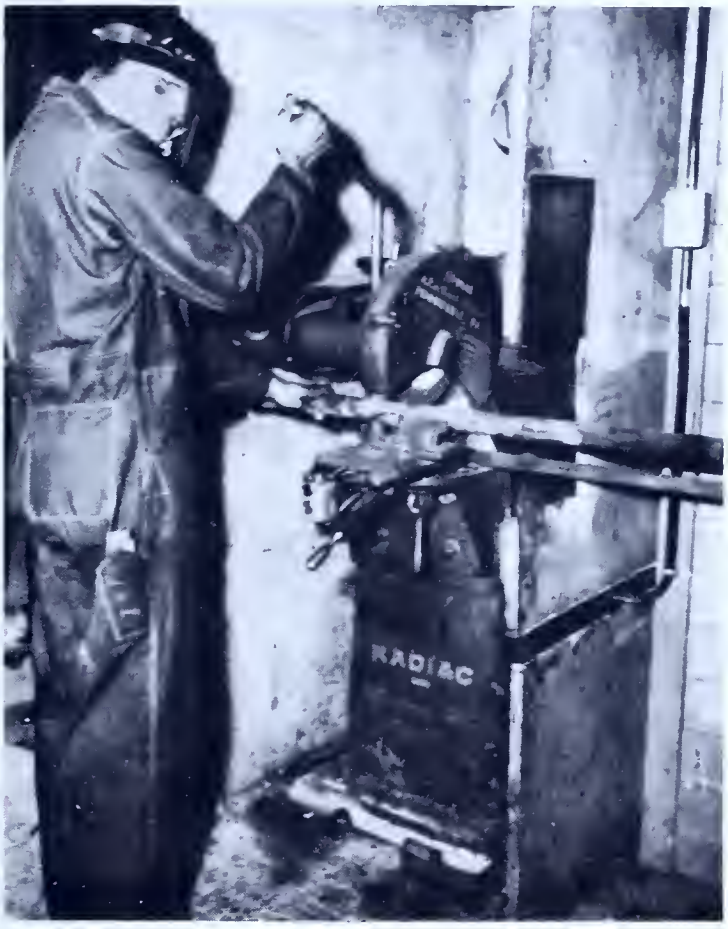


FIG. 266 — *Cutting Pipe*

GENERAL INFORMATION

This cut-off machine makes use of a thin, high-speed grinding disc mounted on a swinging arm. The operator moves the wheel down to the work by means of a handle. It is used to cut pipe, bolts, angle iron, bar iron, etc., up to two inches in size. The principle of operation will be explained by the sketch. Fig. 268.

PROCEDURE FOR OPERATING THE MACHINE

1. Adjust the spring vise (*a*) so that it will hold the pipe securely.
2. Place the pipe on the floor rest (Fig. 267) with one end close to the vise.
3. With the right hand, press down the handle *a*, Fig. 268, to release the spring vise; with the left hand, move the stock through the vise to the desired length.
4. Release the handle of the spring vise; this operation binds the stock in place.

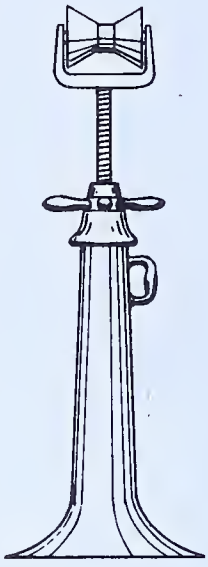


FIG. 267 — *Floor Rest*

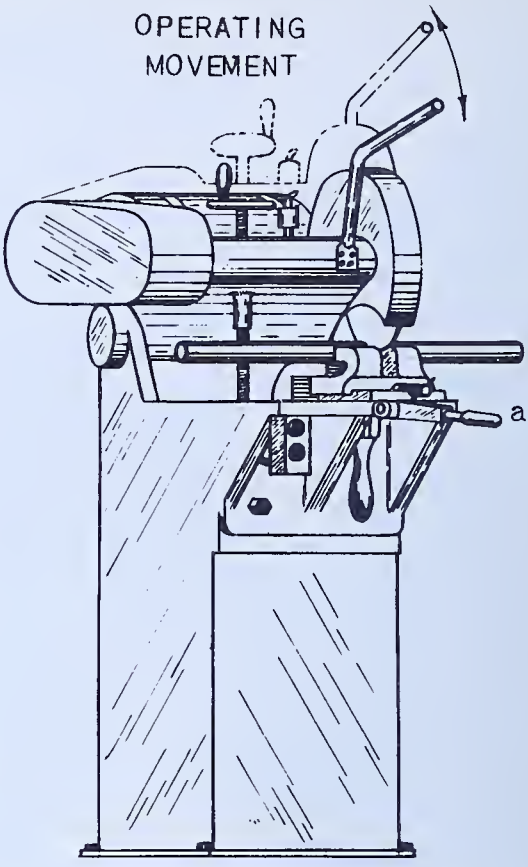


FIG. 268 — *Note Operating Movement*

5. With the right hand grasping the handle, pull the wheel slowly down to the work. See Fig. 266.
6. Use a slow, steady pressure, and hold the disc on the work until the material is cut through.
7. Release the handle. (The wheel is counterbalanced by the motor and will move back by itself).

This operation is repeated until as many pieces as desired are cut. The thin (1/8" x 14" dia.) wheel wears down rapidly and must be replaced when it becomes too small to cut efficiently. The operator must always wear goggles when he works with this machine.

QUESTIONS

1. **Why should goggles be worn when operating the machine?**
2. **How is the pipe held on the machine?**
3. **What must be done when long pieces of pipe are to be cut?**
4. **Why should a slow, steady pressure be used when cutting off material?**

MACHINE OPERATION NO. 4
POWER HACK SAW

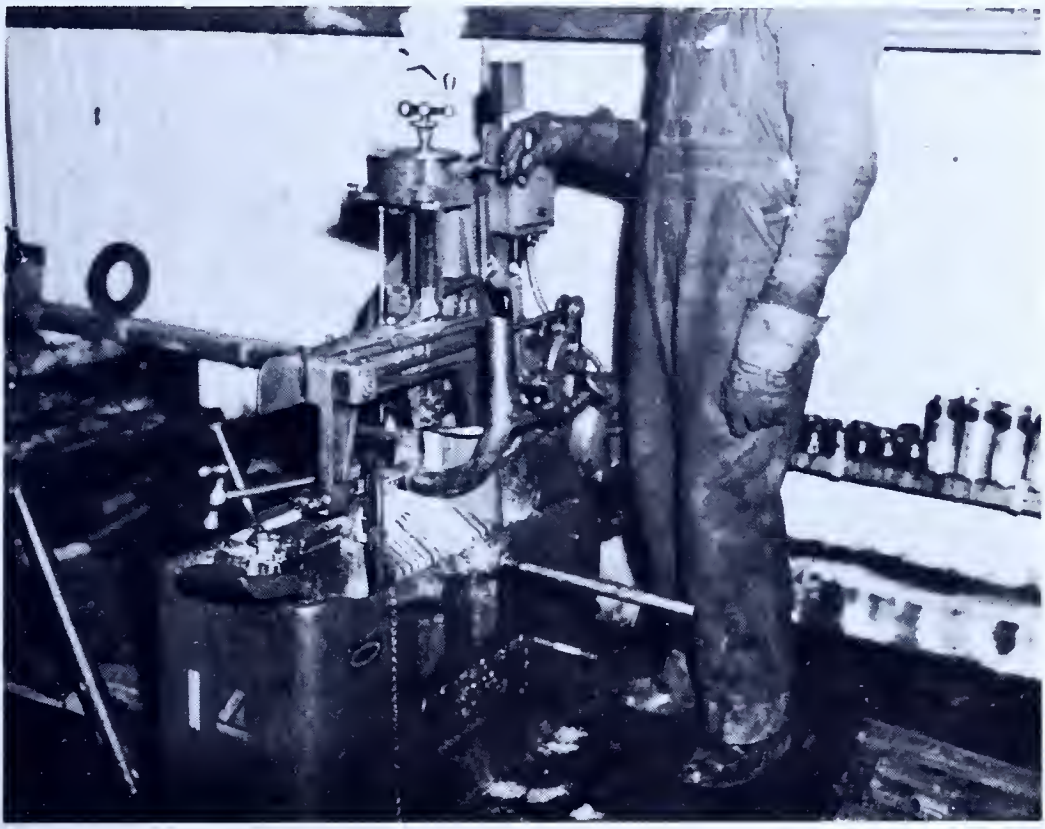


FIG. 269 — *Operating a Power Hack Saw*

GENERAL INFORMATION

The power hack saw is used in the pipe shop to cut stock up to six inches in diameter. A gauge stop on the machine may be set at any desired length; then pieces may be cut off to size without measuring each piece.

(See Fig. 269).

PROCEDURE FOR OPERATING THE MACHINE

1. Place the piece of material on the saw bed.
   Rest one end on the adjustable floor stand. See Fig. 267.
2. Adjust the stand until the stock lies level, or parallel to the floor.
3. Use a rule to set the gauge to the proper distance.
   Tighten the screw on the gauge.
4. Move the stock through the vise until the end touches the gauge.

5. Tighten the vise securely against the work.
6. Start the motor of the machine.
7. Move the saw blade to within 1/8″ of the work, and start the automatic feed. The cutting oil starts flowing as soon as the blade starts moving.
8. When the cut is made, an automatic stop throws off the feed and moves the saw away from the work.

QUESTIONS

1. **When a number of pieces of the same length are to be made, what device is used to gauge the length of the pieces?**
2. **What precaution must be observed when the automatic feed is used?**
3. **What safety feature is provided on the machine?**
4. **Why is cutting fluid used in connection with this machine?**
5. **Why should the saw blade be moved close to the work by hand before the automatic feed is used?**

MACHINE OPERATION NO. 5
COMBINATION CUT-OFF AND PUNCHING MACHINE

General Information

This machine is used to cut off small rod and bar stock and to punch holes in flat stock. The machine is useful in preparing bars that will later be bent into pipe hangers. Bolt holes or rivet holes are quickly and easily punched through flat stock up to ⅝" in thickness. The cutting jaws are located at *a* and the punch is located at *b*. See Fig. 270.

Fig. 270 — *Punching a Short Flat Bar*

An electric motor drives a large geared wheel which in turn drives an eccentric. One revolution of the eccentric performs a punching or cutting operation. The operator inserts the material and operates the machine bv means of a foot treadle.

Procedure for Making Clips

1. Obtain a length of ⅜" x 1½" bar stock and mark off into 10" lengths, using soapstone to mark the bar.

2. Place one end of the bar on a floor rest and insert the other end between the cut-off jaws. The location of the cut is easily obtained by sighting along the line of the jaws.

   The floor stand must be placed in such a position that the stock will be cut off square.

3. Press the foot treadle to cut off the piece.

4. Move the bar through the jaws until the soapstone mark "lines up" with the jaws. Cut off the second piece.

5. Continue cutting the bar until a sufficient number of pieces have been cut off.

6. Mark off the positions for the holes.

7. Insert a piece of stock, perpendicular to the front of the machine, between the punch and die and align for punching the hole.

   Aligning must be done by sight. The operator learns to sight the punch with the mark on the stock, quickly and accurately.

8. Press on the foot treadle and punch the hole.

9. Proceed to punch the next hole.

10. Punch holes in all the pieces.

    After the pieces have been punched they are taken to the hydraulic bending machine where they will be bent to shape.

    Many hangers are bent to shape, taken to the cutoff and punching machine, and are there cut and punched as required.

QUESTIONS

1. **What size of material is cut on this machine?**
2. **Why is the work marked off before it is punched?**
3. **What danger is present when operating this machine?**

MACHINE OPERATION NO. 6
HORIZONTAL HYDRAULIC PRESS

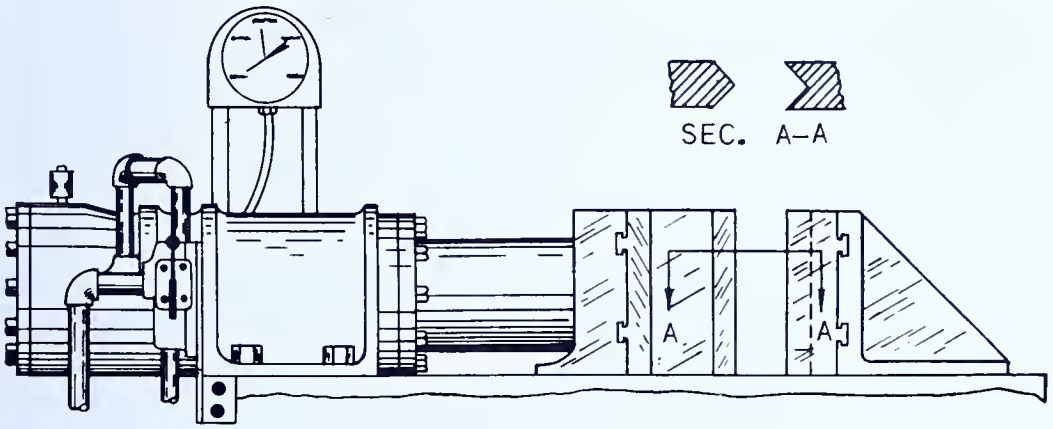


FIG. 271 — *Hydraulic Bending Press*

General Information

This machine is used to bend bar and flat stock. The form shown in the illustration is used to bend 90° angles. Various other forms may be used to bend curves or 45° angles. These forms may be changed quickly by sliding through the tee slots the type of forms wanted. The form shown in Fig. 271 is used to bend 90° angles for straps, clips, and hangers. Curved forms conforming to pipe diameters are used to form the half circles in pipe hangers. A booster pump supplies extremely high liquid pressure for operating the piston. One person operates the machine. He locates the work between the jaws and turns on the valve that operates the piston. After the bending is completed, he reverses the valve and draws the plunger back.

Procedure for Bending an Angle in a Bar

1. Start the motor and wait until the pressure gauge becomes steady.
2. Place the bar of stock between the jaws of the bending form.
3. Sight between the point end of the movable block to the bottom of the vee on the stationary form.
4. Align the mark on the stock with this line of sight.
5. Hold the stock in alignment and open the valve.
6. When the stock has been bent to the proper shape, release the lever.
   This will move the form back to its original position.
7. Remove the bent bar from the machine.

QUESTIONS

1. Why should the forms be located in the tee slots?
2. How is the work located between the forms?
3. What type of work is performed on this machine?
4. Should tempered steel not be bent in this machine? Why?

MACHINE OPERATION NO. 7
AIR OPERATED PIPE BENDING MACHINE

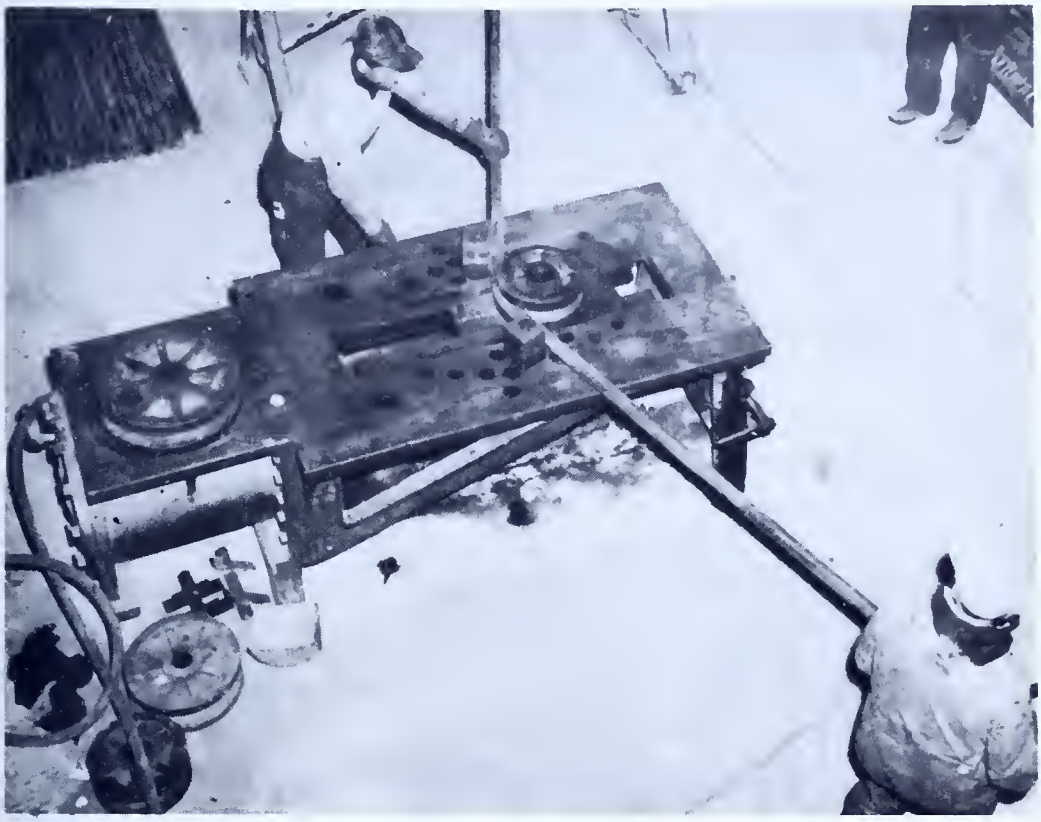


FIG. 272 — *Air Bending Machine*

GENERAL INFORMATION

This machine will bend all sizes of pipe up to and including 2″ in diameter (lead pipe up to and including 4″ in diameter) and to any angle up to 180°. The bend is formed by pushing a wheel-shaped form, grooved on the outside to receive a certain size of pipe, between two limiting pins anchored to the table. Different-sized radius forms are provided for the various sizes of pipe.

The operating principles involved are very simple. See Fig. 273. The piston *a* drives a slide block *b* in which is anchored a pin *c* or hub. A radius form *e* fits over the pin. The guide blocks *d* are set over pins in the proper holes in the table to fit the size of form being used. Pipe *f* is placed on the table between the blocks and the radius form. The center of the bend is lined up with the center of the radius form, and the air is turned into the cylinder. The piston forces the radius form between the blocks. Guide blocks hold the pipe in place. The result is that the pipe is bent to the proper-bend radius. When the proper bend has been made, the air is turned off, the machine reversed, and the pipe is removed.

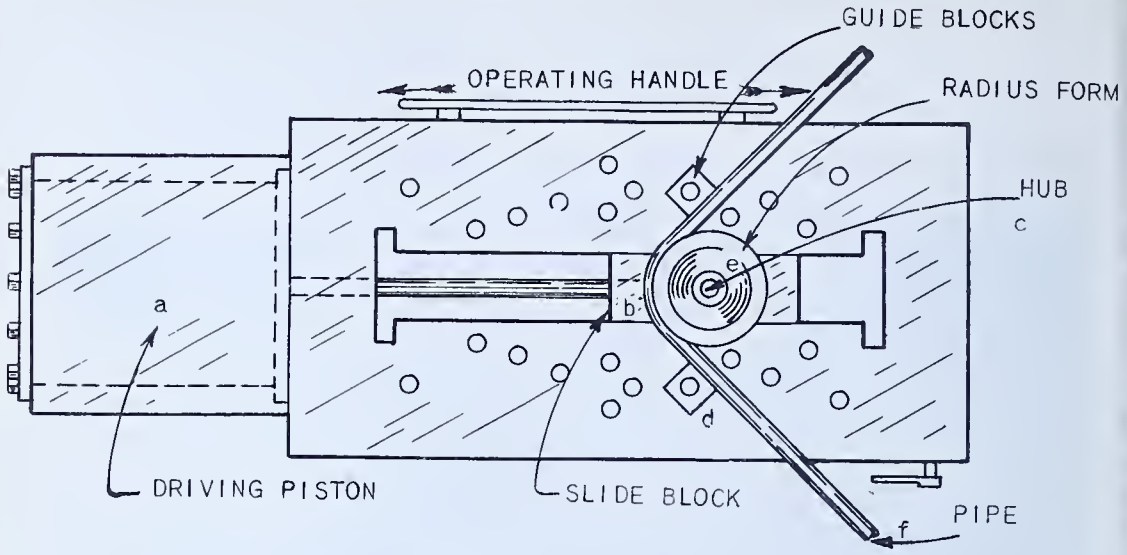


FIG. 273 — *Air Bending Machine*

PROCEDURE FOR OPERATING THE AIR BENDING MACHINE

1. Select the correct bending form for the size of pipe that is to be bent.
2. Place the bending form over the pin in the slide block.
3. Place the guide blocks in their proper holes.

   These blocks must be located in such a manner that the form and pipe will clear the blocks without flattening the pipe. The amount of bend and the size of the pipe and form must always be considered when locating the guide blocks.
4. Have the helper assist in placing the pipe on the machine.

   If the bend is to be close to one end, the helper must hold the other end level with the table.
5. Locate the center of the bend on the pipe and mark with soapstone.
6. Align the mark on the pipe with the center of the bending form.
7. Turn on the air until the form wedges tightly against the pipe.
8. Place the template over the pipe and again turn on the air until the proper bend has been obtained.
9. Reverse the machine and draw the form back to its original position.
10. Remove the pipe from the machine.

QUESTIONS

1. **Why, when bending a pipe, should the operator stand on the outside of the bend?**
2. **Why are different sized forms used?**
3. **What is the purpose of the guide blocks?**
4. **What is a radius?**
5. **What is a radius form?**

MACHINE OPERATION NO. 8
SIX INCH BENDING MACHINE

General Information

This machine will bend up to 6″ extra-strong pipe to any angle up to 180°. Two men are needed to operate this machine. The pipe is placed in the machine against a circular form *a* on one side, and on the other side, against a straight guide form *d* and a grasping form *c* geared to the electric motor. These forms, made to accommodate all sizes of pipe, from 2½″ to and including 6″, are grooved to fit the shape of the pipe. This groove keeps the pipe from flattening when it is bent. The revolving circular form has a radius of five times the diameter of the pipe for which it was designed. Thus, a 4″ pipe would use a 20″ radius form; a 6″ pipe would use a 30″ radius form.

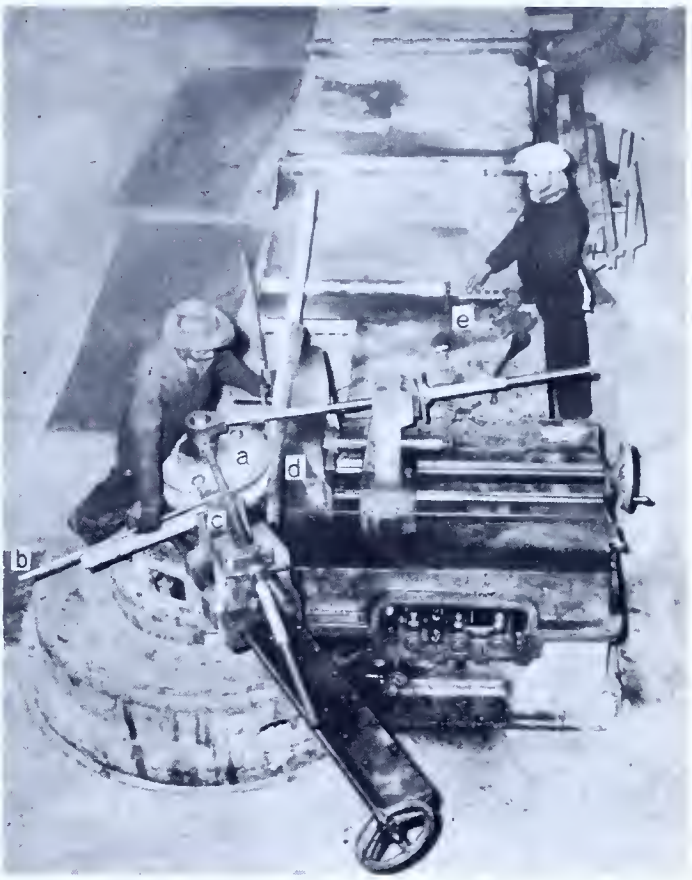


Fig. 274 — 6″ *Pipe Bending Machine*

Procedure for Operating the Six Inch Bending Machine

1. Place the template *b* around the radius form, and mark the template and the radius form where the bend begins.

   Remove template and mark pipe according to template.

2. Insert the pipe in the machine until the marks on the pipe are even with start of the grasping form so that the bend will start at the correct place.

3. Tighten the grasping form against the pipe.

4. Have the helper move the long guide form up against the pipe.

5. Hold the template around the radius form, and have the helper start the machine by pushing the button marked FORWARD. See *e*, Fig. 274.

6. When the pipe has been bent to the same angle as the template, have the helper stop the machine.

7. Reverse the machine a bit to relieve the strain.

8. Loosen the forms.

   Sometimes it will be necessary to hit the pipe with a maul to break it loose from the form.

9. Reverse the machine to its normal position and remove the pipe.

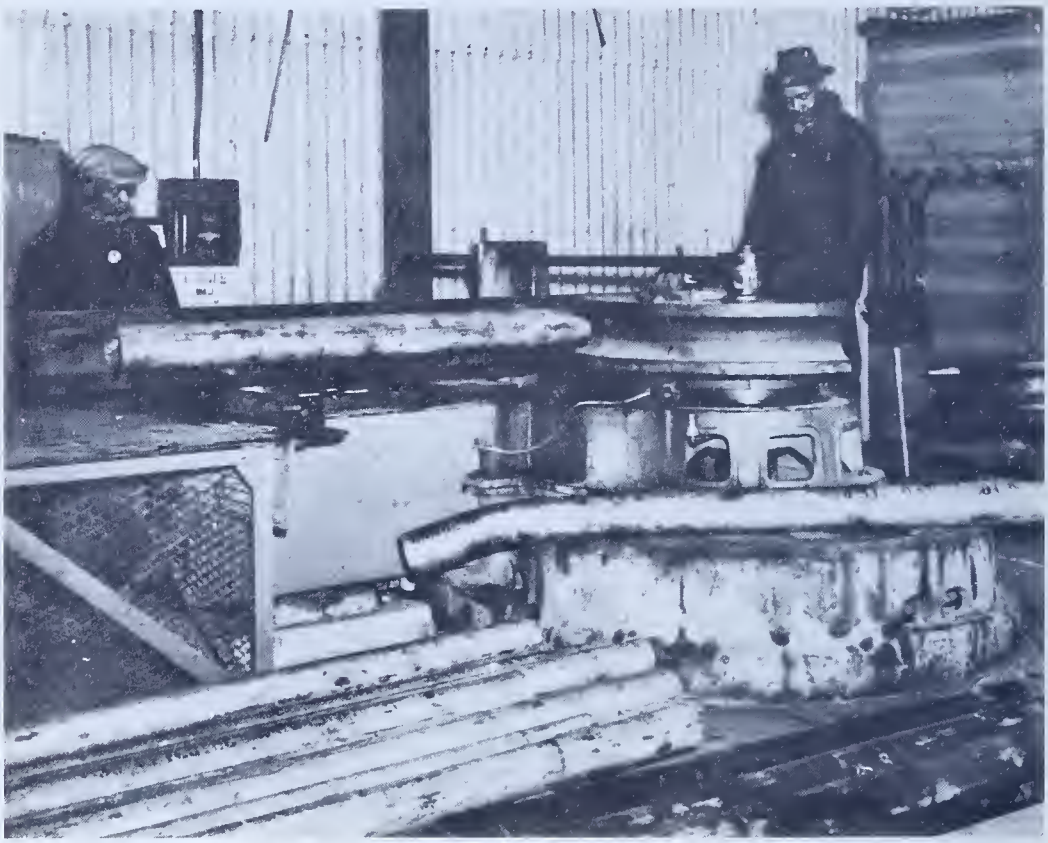


FIG. 275 — *Bending a Piece of 5″ Pipe*

QUESTIONS

1. **Why should the template be marked before it is used to gauge the bend in the pipe?**

2. **What is meant by "recommended bend radius equals five times the diameter of pipe"?**

3. **Why should the pipe be marked the same as the template?**

4. **Why is the bend carried a bit beyond the required angle?**

MACHINE OPERATION NO. 9
HOT BENDING

General Information

Pipe over 6″ in diameter, or pipe that has to be bent beyond the recommended bend radius, must be heated before it can be bent. In order to prevent the pipe from flattening on the bend, the pipefitters must pack the pipe with sand. See Fig. 276.

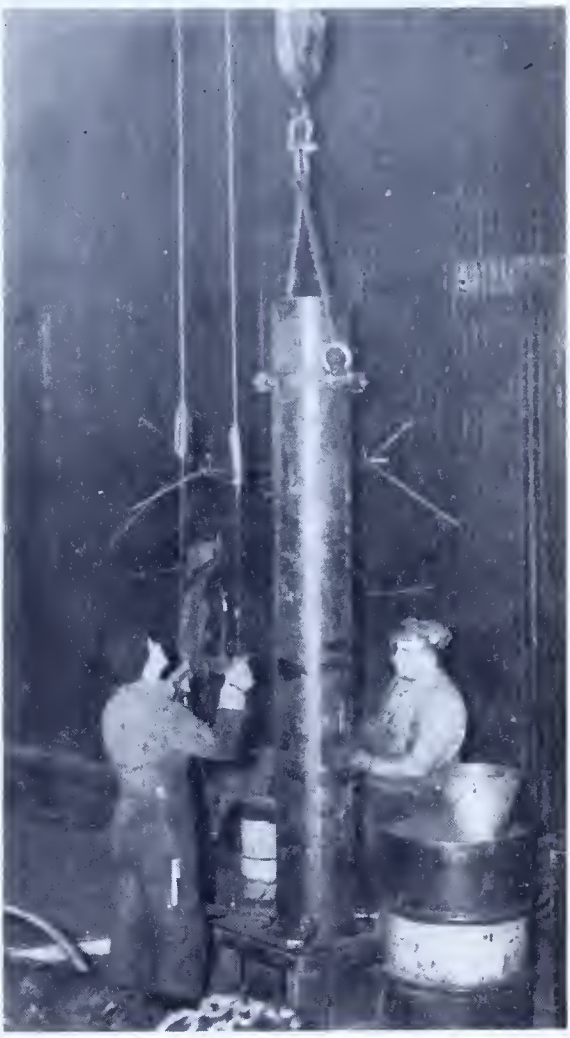


Fig. 276 — *Packing Pit*

Procedure for Packing Pipe With Sand

1. Using a maul, drive a wooden plug tightly into one end of the pipe.
2. Fasten a clamp around the pipe about 30″ from the opposite end.
3. Fasten a hoist to the clamp, and hoist the pipe until it clears the table.
4. Lower the pipe into a hole made for this purpose. Fig. 276.
5. Fill the pipe with sand.

   The sand is loosely packed and must be settled. Air hammers are fastened to the edge of the table for this purpose.
6. Turn on the air for the air hammers.
7. While hoisting the pipe up and down and turning the pipe continually under the hammers, the sand will be packed tightly in the pipe.

   Sand will have to be shoveled in until the sand no longer settles.
8. When the sand stops settling, drive a wooden plug into the open end of the pipe.
9. Remove the pipe from the hole, and place it upon the hot table.
10. Remove the clamp.

    The pipe is now ready for heating and bending. Bending is done on a heavy iron table containing square holes spaced 4″ apart. These holes receive pins and dogs which hold the pipe in place.

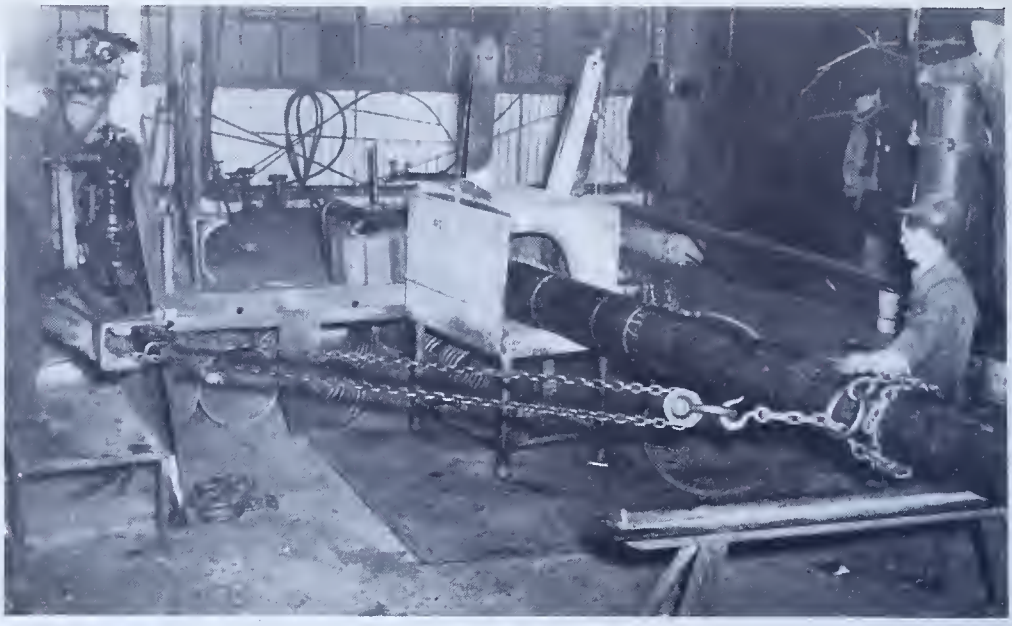


FIG. 277 — *Hot-bending Plate and Furnace*

PROCEDURE FOR HOT-BENDING A PIPE

1. Mark the pipe according to the start of the bend on the template.
2. Using the pins and dogs, fasten, to the table, the end closest to the bend.
3. Fasten a chain from the motor to the other end of the pipe.
4. Push the furnace up to the pipe where the bend is to be made.

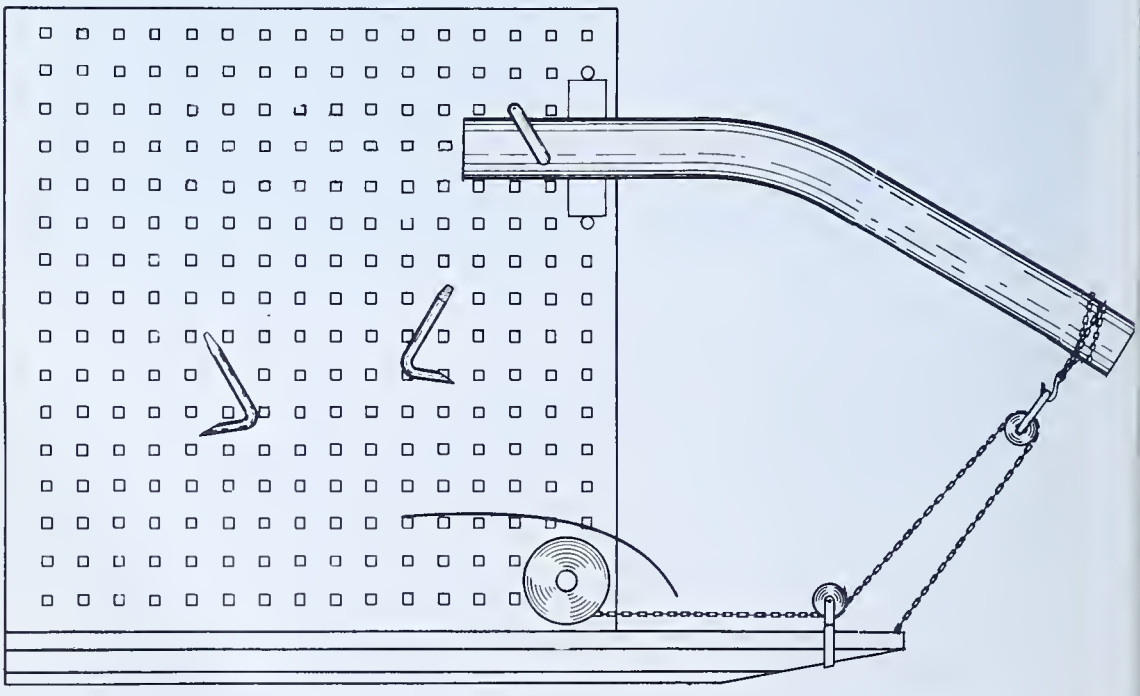


FIG. 278 — *Sketch of Bending Table*

5. Heat the pipe until it is red hot, and then remove the furnace.
6. Place the template over the pipe so that the correct bend may be followed.
7. Signal the helper to operate the motor until the correct bend is obtained. See Fig. 278.
8. Remove the pipe from the table, and remove the sand. As a matter of safety, write (soapstone, or chalk) the word HOT on the portion that was heated.

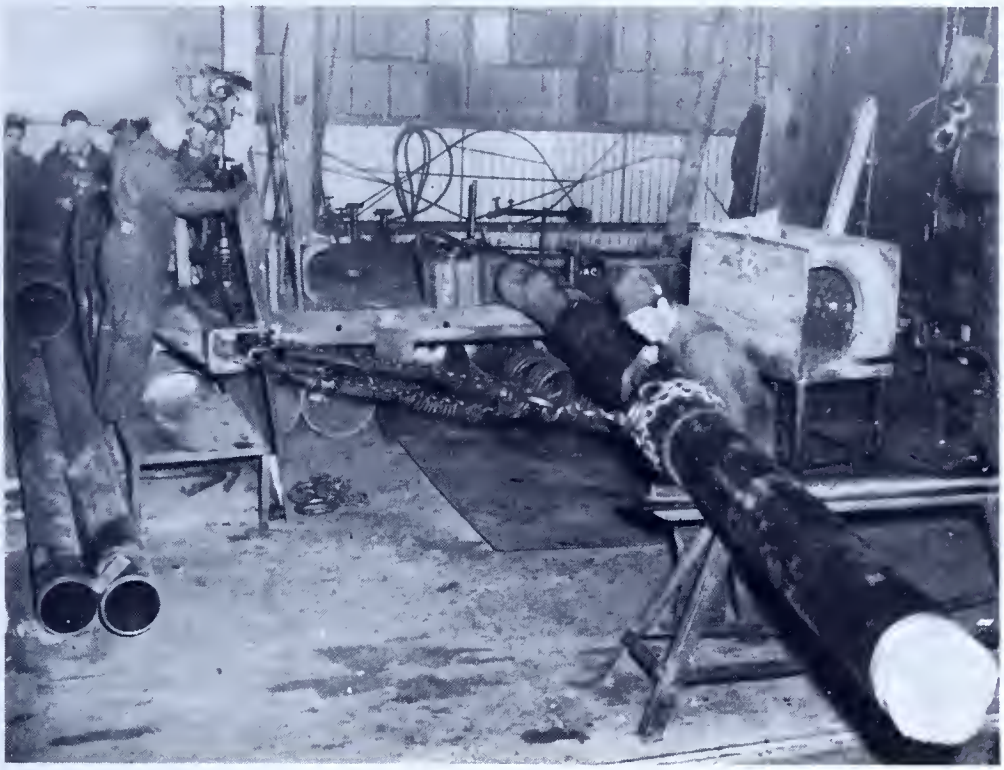


FIG. 279 — *Hot Bending a Large Pipe*

QUESTIONS

1. **Why is it necessary to heat pipe before it is bent?**
2. **Why is a floor stand used under the loose end of pipe while it is being bent?**
3. **Why should the part, that has been heated, be marked "Hot"?**
4. **How can the operator tell when the pipe has been bent to the proper angle?**
5. **Why must the sand, used to pack the pipe, be dry?**

MACHINE OPERATION NO. 10
REVOLVING-DIE THREADING MACHINE

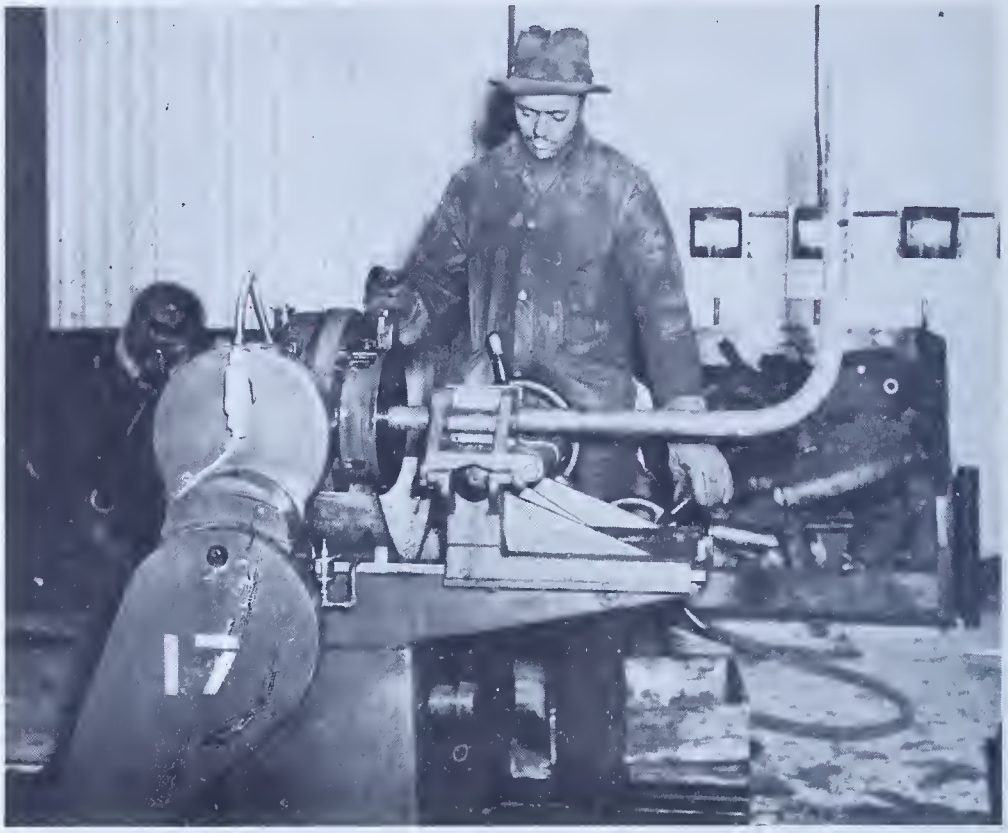


FIG. 280 — *Typical Threading Machine*

GENERAL INFORMATION

This machine is capable of cutting and threading pipe from ½″ to 4″ in diameter. Pipe that has been bent can be threaded. One man can very easily operate the machine for any job that may arise. Each set of dies will cut threads on two sizes of pipe. The change is made by moving a quick-acting clamp in the revolving head to an alternate position.

A vise mounted on the movable carriage simultaneously clamps the pipe and centers it. The dies are connected inside the revolving head to the quick-acting change lever. The position of the dies must be checked by means of a plate on the outside of the revolving head. Graduated markings on the face of this head indicate the size for which the setting is made. To remove the dies, the operator must loosen four set screws holding the four dies. This procedure permits the dies to be extracted from the inside of the head.

The cut-off tool is located behind the dies. It may be turned in by hand, or the

automatic feed lever can be engaged. This lever is hinged to the revolving head so that at each revolution of the cutting head the feed knob is caught and turned slightly.

PROCEDURE FOR OPERATING ONE TYPE OF THIS MACHINE

1. Insert the pipe into the vise far enough to provide sufficient space for the carriage to move for the performance of the necessary operations.
2. Clamp the vise jaws tightly against the pipe.
3. If the pipe is to be cut off, disengage the dies by moving the quick-action lever on the revolving head to the last position (away from the operator).
4. Start the motor, and move the carriage into position so that the tool will cut on the mark made on the pipe.
5. Start the oil; force the cutting tool against the pipe.
6. Engage the automatic feed.
7. After the pipe has been cut off, move the carriage back beyond the dies.
8. Stop the machine, and set the dies to the proper position for the size of pipe being threaded.
9. Start the motor, and bring the carriage up slowly until the dies engage the pipe.
10. After several threads have been cut, the operator will not have to keep feeding the pipe into the machine. The threads will pull the pipe through the dies. When the proper length of thread has been cut, stop the machine.
11. Disengage the dies, and move the carriage away from the dies.
12. Disengage the vise clamp, and remove the pipe.

QUESTIONS

1. **How can the operator tell when the threads have been cut deep enough?**
2. **How are the dies changed?**
3. **How many sizes of pipe can be cut with one set of dies?**

MACHINE OPERATION NO. 11
REVOLVING PIPE-THREADING MACHINE

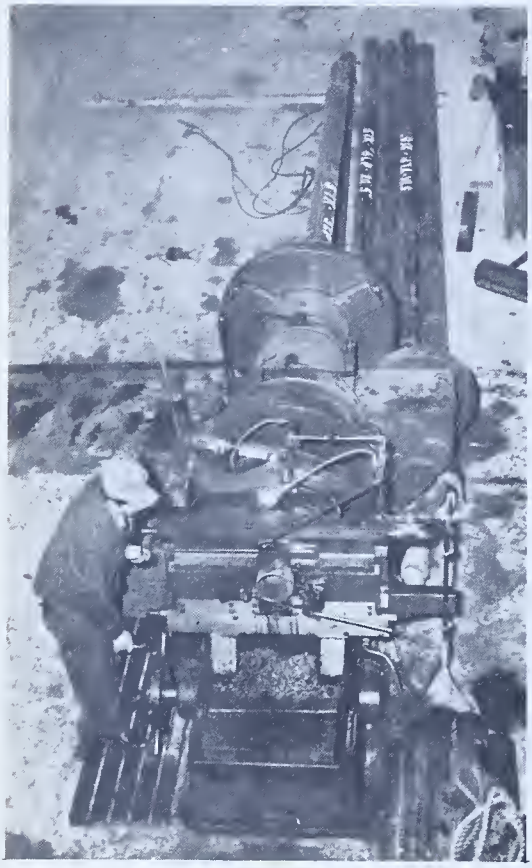


FIG. 281 — *Grooving Pipe for Victaulic Coupling*

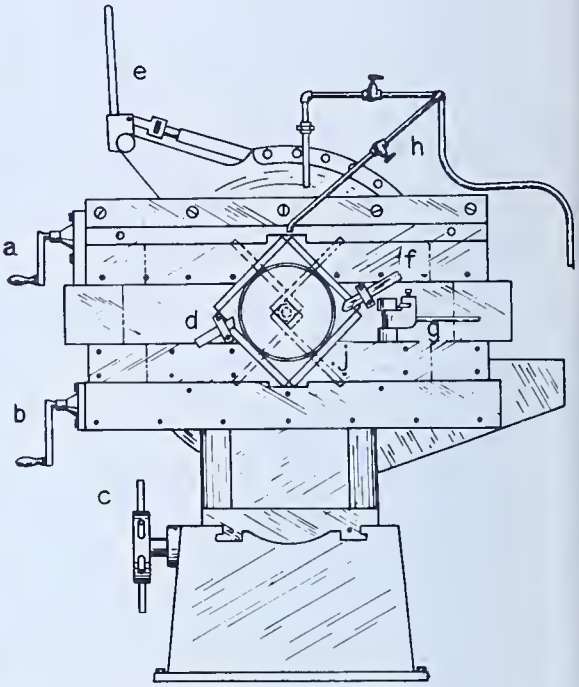


FIG. 282 — *Front of Threading Machine. Solid Lines Show Large Pipe in Machine; Dash Lines Show Small Pipe*

GENERAL INFORMATION

This machine will cut, thread, or bevel, both inside and outside, pipe ranging in size from 4″ to 12″. It will also groove the pipe to fit victaulic couplings. (See Part IV). The pipe is fitted inside a driving drum and clamped into place by means of six toothed jaws. These jaws are individually adjusted by means of adjusting screws. Marks on the front and rear jaws indicate the various jaw positions for the various sizes of pipe handled by this machine.

The smaller sizes of pipe are inserted into the machine by two men. Larger sizes have to be lifted into the machine with a crane. When the pipe has been inserted in the machine to the proper position, the jaws are turned down tightly against the pipe. The cutting head is then moved by means of a wheel *c* located near the bottom of the machine to the proper position for the cut. If the pipe is to be cut off, reamed,

beveled, or grooved, the bearing jaws or V blocks *j* are turned snugly against the pipe to prevent its chattering. When the pipe is properly located and braced, the machine is started and the operation is performed.

Cutting off and outside beveling are done with the same tool *d*, located and operated on the operator's side of the machine. Grooving is accomplished by means of a tool *f* located on the opposite side of the head. Inside beveling or reaming is done by means of a tool *g* hinged to the opposite side of the head. The operator grasps the handle and swings the tool around (toward the operator) until the tool engages the pipe.

In order to thread the pipe, the operator releases the V jaws and moves the carriage forward until the dies clear the end of the pipe. The position of the dies must then be adjusted for the size of the pipe to be threaded. Then the handle *c* that closes the dies is pulled down until it is locked in place. The machine is started, and the operator moves the carriage up slowly until the dies have engaged and cut several threads on the pipe. These few threads will then pull the carriage and dies along without the aid of the operator. When the proper length of thread is cut, the handle controlling the dies is pushed up and the machine is stopped.

Procedure for Preparing a Pipe End for a Victaulic Coupling Joint

1. Have the pipe lifted to the level of the opening in the machine.
2. Check to see that the gripping jaws are opened wide enough to permit the pipe to enter the machine.
3. Slide the pipe into the machine, leaving sufficient pipe to extend beyond the front of the machine to perform the necessary operations.
4. Turn the gripping jaws down on the pipe with the wrench provided for that purpose.
5. See that the pipe is properly aligned.
6. Locate the cutting head by turning handle *c*.
7. When the head is properly located to perform the work, tighten the bearing jaws *j* by means of handle *a*.
8. Start the machine and move the cut-off tool *d* against the pipe to see that it will cut on the mark around the pipe.

   The cutting head may have to be moved by handle *c* to locate the cut properly.
9. Adjust the cutting-oil pipe so that the oil will flow over the cut.
10. Turn the cutter slowly in by means of handle *b* and cut off the pipe.
11. Continue turning the tool into the work a very slight amount.

    This will move the beveled edge of the cut-off tool into position for beveling the end of the pipe. See Fig. 283.

12. Turn the cutting tool in against the pipe and bevel the edge until the burr is removed.
13. Turn the cutting tool back.
14. Reach across the front of the machine and grasp the reaming tool.

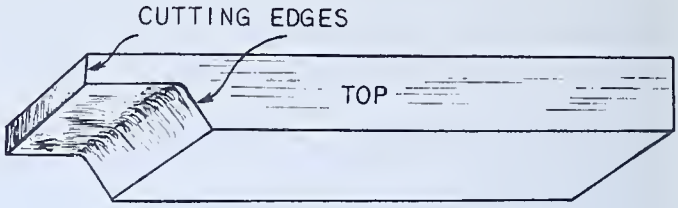


FIG. 283 — *Cut-off Tool*

15. Pull the handle of the reaming tool *g* forward until the reaming tool comes into contact with the inner edge of the pipe.
16. Pull on the reaming tool handle until the burr on the inner edge of the pipe is removed.
17. Push the reaming tool away from the work.
18. Stop the machine.
19. Move the machine head front until the grooving tool will clear the end of the pipe.
20. Select the proper size of grooving tool for the size of pipe being prepared, and fasten it in the proper position for the cut. Refer to the chart (fastened on the shop wall by the machine) for the dimensions of victaulic coupling grooves.
21. Move the head back until the stop on the grooving tool rides on the end of the pipe.
22. Turn the cutting tool against the pipe with handle *b*, and cut the groove. The depth of the groove is checked with an outside caliper set to the proper opening.
23. Stop the machine and remove the pipe.

QUESTIONS

1. **How many sizes of pipe will this machine cut?**
2. **How are large pipes put into this machine?**
3. **What operations other than cutting and threading are done on this machine?**
4. **Why is cutting oil used in connection with the operation of this machine?**

PART VII
THE CONSTRUCTION AND USE OF TEMPLATES

Types of Templates and Their Uses

A Template is a Pattern

The marine pipefitter is often required to make templates. A template is a pattern that has been cut, bent, or molded to some pre-determined shape. This pattern is then used to gauge the shape of the actual piece to be fitted.

Some templates are straight edges, and some are curved pieces, such as bent rod; some templates have multiple-curved edges; still others are like discs, or parts of discs. Whatever the shape may be, it is a pattern for fitting some other piece of material. The pipefitter forms the template either from a layout drawing or by bending the template aboard ship to fit actual conditions on the ship.

Disc Type of Template

Sometimes templates have to be made of flanges for the cutting-out of gaskets. The easiest way (whenever it is possible) of making a template of this type is to lay the template material on the flange and then, using a ball-peen hammer, strike on the holes and rim to cut out a template of the exact shape. The template may then be placed over the gasket material and marked out. All gaskets laid out by this template will be the same size. After a sufficient number have been made, the template may be stored away for future use. It is apparent that this method saves a great deal of time.

Wire Templates

Wire templates are seldom used, and then only where short thin pipes are to be bent. The use of wire is limited because wire is easily sprung out of shape. Its use will not be covered in detail here because the discussion of wire template would be exactly the same as that of pipe template.

Layout Template for Cutting Pipe

Certain cases arise in pipe fitting practice that necessitate the development of this type. Assume that a large pipe were to meet a trunk line at an angle. Certain conditions would prevent the using of standard threaded fittings. Here would be found a case where a template would have to be laid out so that the pipe could be marked for cutting.

Pipe Templates

The most useful template to the pipefitter is one made of pipe. ¼", ⅜", or ½" pipe is used to make templates for piping installations. The size of pipe and the amount of offset determines, to a certain extent, the size of pipe to be used in making the template. Pipe is used for the larger installations because it is more rigid than wire. If the amount of offset or the length of pipe is exceptionally long the template may have to be braced by having a straight piece of pipe welded across the bends.

Wood Templates

Board templates are used wherever it is necessary to maintain perfect fixed points and exact face-to-face contacts. Light lumber, that is easy to work, is used to fabricate these templates. These wooden templates will not be damaged or distorted by rough handling as easily as rod or pipe templates.

The reasons for using pipe templates may be summarized as follows:

1. If several pipes have to be bent along the same lines, the use of templates will insure uniformity.
2. The template can be made up on board ship to meet certain conditions and then the pipe can be bent in the shop.

   There are no facilities on board ship for bending the larger pipes.
3. The template can be used on other ships of the same design.

Using the Template

To understand how a template is used as an aid when bending pipe will greatly assist the beginner in learning how to make a template.

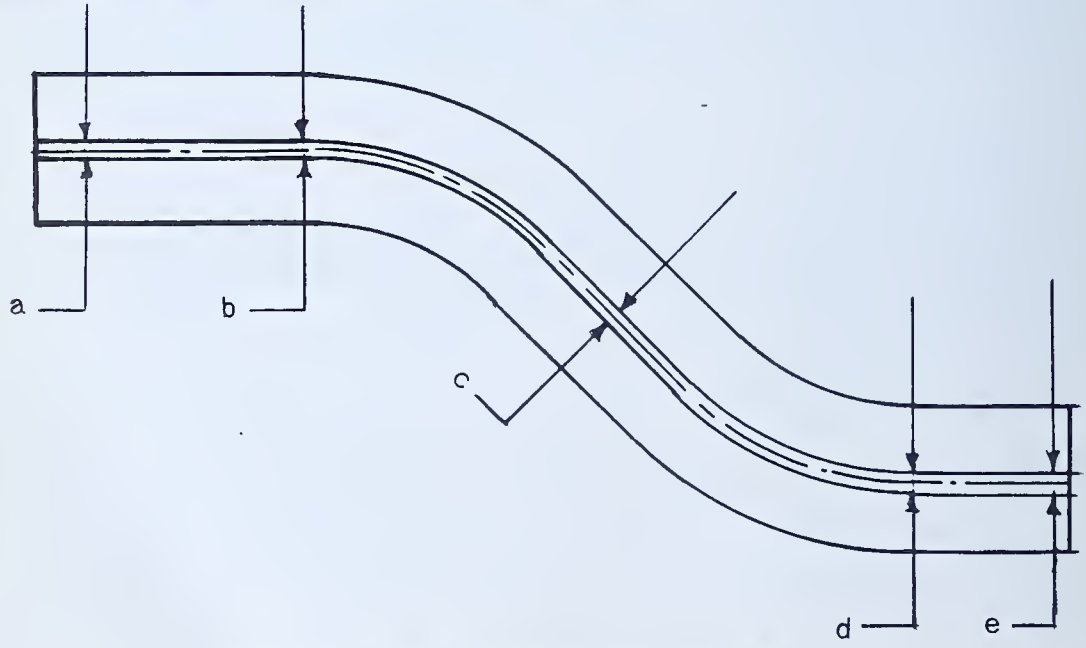


Fig. 284 — *Bend a Six-Inch Pipe to a Template*

Let it be understood that when the center line of a pipe conforms to the shape of the template, the outside walls of the pipe will be the correct shape. A template is shown (Fig. 284) as it lies along the center line of a pipe bend.

The template (made of $\frac{3}{8}''$ pipe) lies exactly along the center line of the six-inch pipe. The central location of the template on the larger pipe can be checked by using a square on either side and measuring from the square to the template. This method is shown in Fig. 285.

When the end of the template centers at *a*, Fig. 284, clamp it in place and proceed to check the central location at several other points as at *b*, *c*, *d*, *e*, etc. A good mechanic can align the template by "sight" instead of having to use squares to check the work.

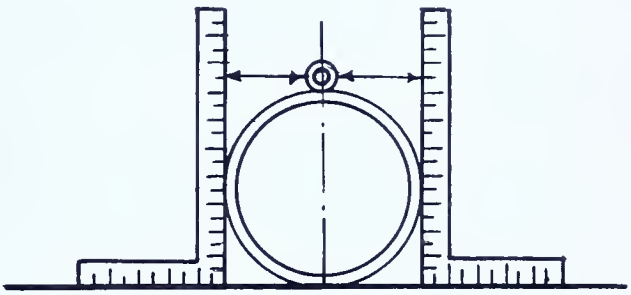


FIG. 285 — *Checking the Central Location of the Template*

It will be noted that the template is cut to the exact length of the finished job. This is necessary to avoid having the bend come in the wrong place. The incorrect procedure is clearly shown in Fig. 286.

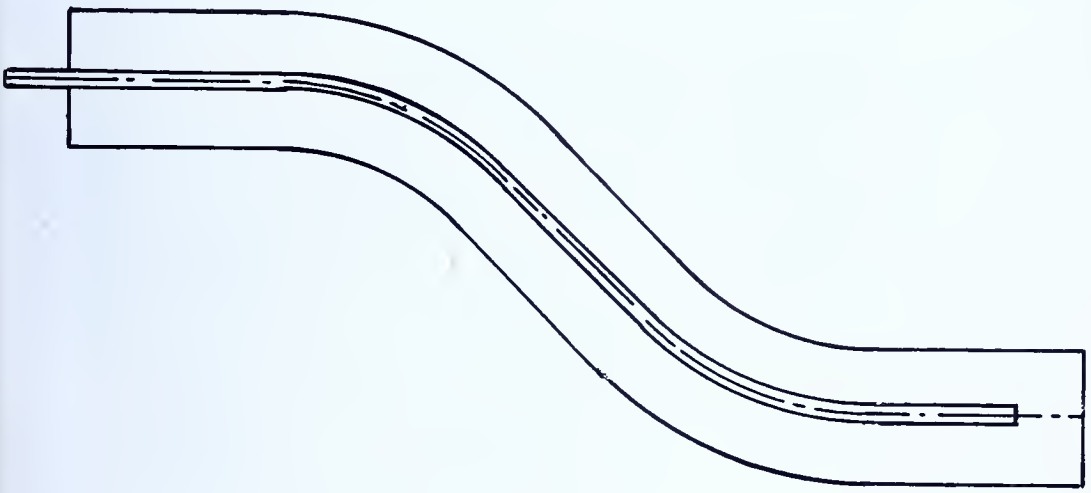


FIG. 286 — *The Pipe is Bent Correctly but the Template Shows the Bend too Close to One End*

When bending the six-inch pipe the mechanic must be careful to have the bend come at the right distance from the end. It is much easier to locate this position while bending the pipe than it is to correct it after the pipe has been bent.

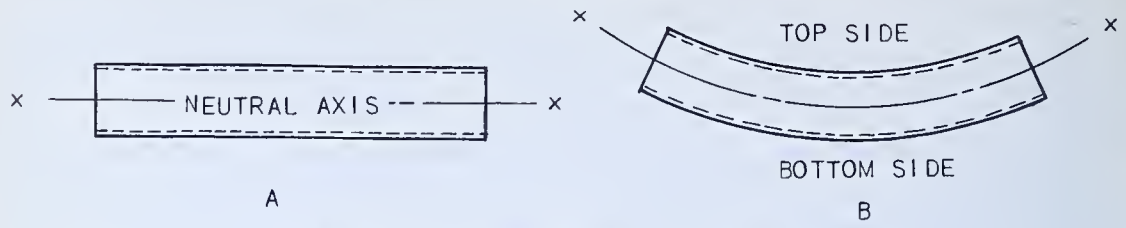


FIG. 287 — *Neutral Axis of a Pipe*

NEUTRAL AXIS

Two illustrations of a piece of pipe are shown in Fig. 287 at *A* and *B*.

Line *x-x* in Fig. 287 at *A* is the neutral axis of the pipe and it passes directly through the center of the pipe. Figure 287-at *B* shows the pipe after it is bent. Something has happened to the pipe while bending it. The top side, the neutral axis, and the bottom side are all of different lengths. It is the same pipe but the top side is shorter and the bottom side is longer than the measurements taken at the same places in Fig. 287 at *A*. The bending of the pipe has caused the top side of the pipe to "upset" (get shorter), and the bottom side to "stretch" (get longer). The length of the neutral axis is the same in both *A* and *B*, Fig. 287.

From the foregoing it should be clear that all measuring for pipe bends should be done on the neutral axis. Measurements for compound bends (two or more bends) are taken in the same manner.

SUMMARY

The necessity of checking a template before it is used as a pattern for bending a pipe cannot be over emphasized. If the template has been bent wrong, the pipe bent over the template will not fit and valuable time will be wasted in rebending the pipe or bending a new piece of pipe. The use of templates becomes a time and effort saver only when the template is correctly made. Frequently blueprints do not follow actual conditions on board ship and a template made from a blueprint might not suit actual conditions. For this reason all templates bent according to a blueprint should be taken aboard ship and fitted into place. If this is done, very little difficulty will be encountered in installing pipes bent from a template.

Whenever several ships of the same general design are to be constructed, the templates made for the first ship should be saved, labeled, and stored in some place where they will not be bent. The label tied to a template should indicate the part number and drawing number so that it can be readily identified.

The templates are usually hung on nails or clips fastened to the shop walls. If a template had been roughly used it should be checked before using.

QUESTIONS

1. Describe the use of a template.
2. In pipefitting, for what are disc templates used?
3. Why are pipe templates important to the pipefitter?
4. Why are all measurements taken from centerlines?
5. Why is the centerline of a pipe termed the "neutral axis"?

JOB SHEET NO. 1
TO MAKE A LAYOUT FOR FIG. 288

General Information

The blueprint for certain pipe line installation comes into the pipe shop. After studying the dimensions and general arrangement which are given on the blueprint the mechanic must first make on the shop floor a layout of the pipe line.

The layout is an exact full-size duplicate of the lines which represent the pipe on the blueprint. The center lines are important for it is around the center lines that the pipe outside diameter and length are laid out. The center lines are the ones over which the templates are bent.

The pipe installation shown in Fig. 288 indicates that a 90° bend must be made in a piece of 5″ pipe. The pipe is flanged (fitted with flanges) at both ends and it must drop into place to make a perfect joint with the mating flanges.

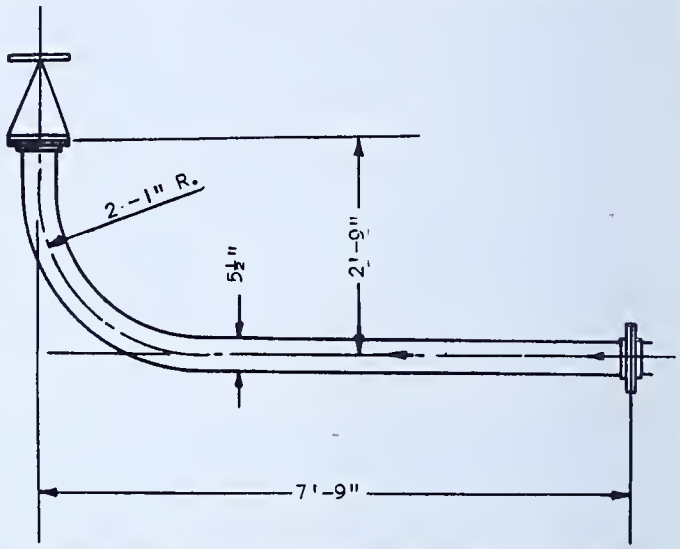


Fig. 288 — *Five-Inch Pipe with a 90° Bend*

Make a rough dimensioned sketch of the center lines that will be required for the layout. The dimensions are obtained by scaling the blueprint. A sketch like this will save time when laying out the center lines on the floor. Check the center-line dimensions for accuracy so there will be no mistake when the layout is made.

Tools	Materials
1. Folding rule	Chalk
2. Trammels (Three-foot beam)	Soapstone
3. Chalk line	
4. Steel square	

Procedure

1. Sweep clean a portion of the shop floor about 10′ long and 6′ wide.
2. Strike, with the chalkline, a line along one of the longer sides of the cleaned area. This will be the center line of the long reach of pipe.

3. Using a steel square, erect at one end of the center line, a perpendicular. This is the center line of the short reach of pipe.

4. Figure 289 at *o* marks the point where the two center lines intersect. From this point, measure along the long line a distance of 7′ 9″ (the length of the long reach of pipe) and mark with soapstone.

5. From the same point (*o*) measure along the shorter center line a distance of 2′ 9″ and mark with soapstone. This will be the length of the shorter reach of pipe.

6. Set the trammels to 2′ 1″. This is the recommended bend radius of 5″ pipe and is found by multiplying the nominal diameter by 5.5″ x 5 = 25″ or 2′ 1″.

7. Place one trammel point on the intersection *o* and scribe two arcs cutting both center-lines as shown at *a* and *b* on Fig. 289.

8. Using the same setting, place one trammel point on *a* and scribe an arc *e* inside of the angle; then place the trammel point on *b* and scribe an arc *f* inside of the angle. The two arcs will intersect and form the center of the arc for the bend of the elbow.

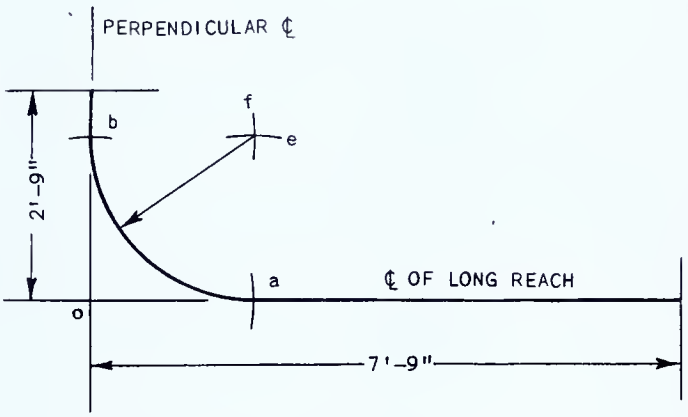


FIG. 289 — *Center Line Layout*

9. Place a trammel point on the intersection of the two arcs *e* and *f* and scribe an arc from point *a* to point *b*. This will be the bend over which the template is to be made.

QUESTIONS

1. **What is meant by bend radius?**
2. **Explain the term "recommended minimum bend radius equals five times the nominal diameter of the pipe".**
3. **Why are center lines used for the layout for bending a template pipe?**
4. **What is meant by "point of intersection"?**

JOB SHEET NO. 2
TO MAKE A LAYOUT FOR FIG. 290

General Information

The layout for this job is made in a similar manner to the layout for Fig. 288. The bends in the pipe shown in Fig. 290 are not as sharp, but the procedure for finding the centers of the arcs is much the same as in the preceding work.

Tools

1. Folding rule
2. Trammels (6′ beam)
3. Chalk line
4. Straightedge
5. Steel square

Materials

Chalk
Soapstone

Procedure

1. Sweep clean a section of the shop floor approximately 10′ long and 4′ wide.
2. Strike with the chalk line two center lines exactly 1′ 4″ apart and parallel to each other in the center of the cleaned floor. Label these *a-a* and *b-b*.
3. Using the steel square and soapstone, square a line *c-c* across the top end of center line *a-a* as shown in Fig. 291.
4. Measure along lines *a-a* from *c-c* a distance of 7′ (the length of the pipe section) and mark this point *e*.
5. Square a line through this point to line *b-b*. This line is labeled *d-d*. Where this line cuts center line *b-b*, (at *g*) will be one end of the pipe; the other end will be at the intersection of *a-a* and *c-c*.

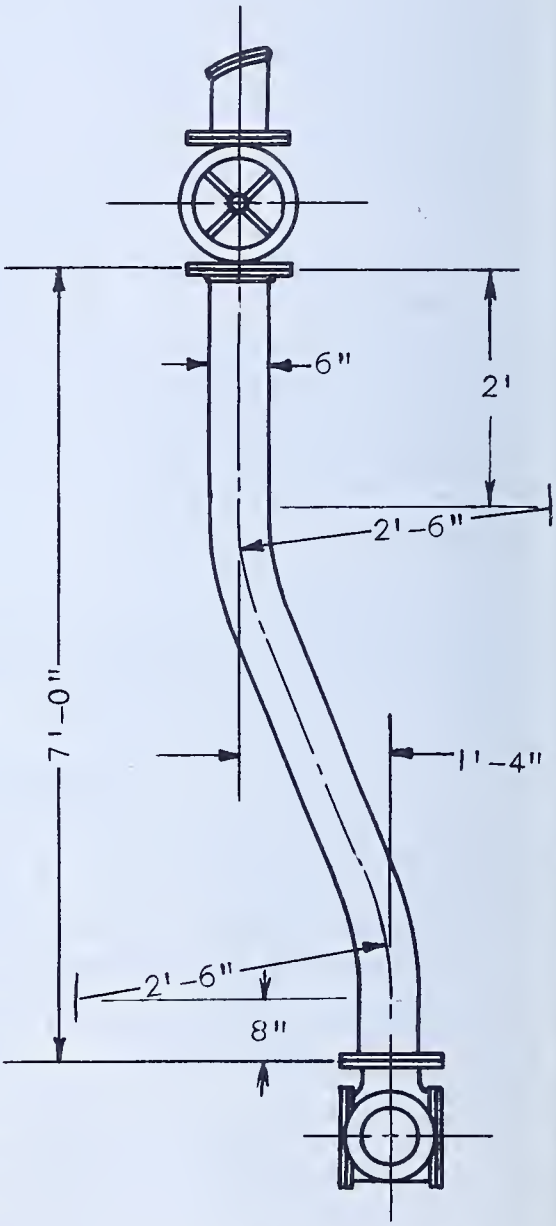


FIG. 290 — *Measurements Are Scaled from the Print*

6. Measure from line *c-c* along center line *a-a* a distance of 2′ (the distance from the top flange to the start of the bend) and mark this point *k*.

7. Using the steel square erect a perpendicular to *a-a* through point *k*. Label this line *m-m*.

8. Since a 6″ pipe is used, multiply this diameter by 5 to get the correct bend radius, which is 30″ or 2′ 6″.

9. Lay out this distance (2′ 6″) from *k* on line *m-m* and mark this point *v*.

10. From point *v* strike an arc using trammels (or soapstone and a piece of string) set to the bend radius 2′ 6″.

11. Refer to point *g* and measure 8″ in from this point along line *b-b* and mark this point *t*.

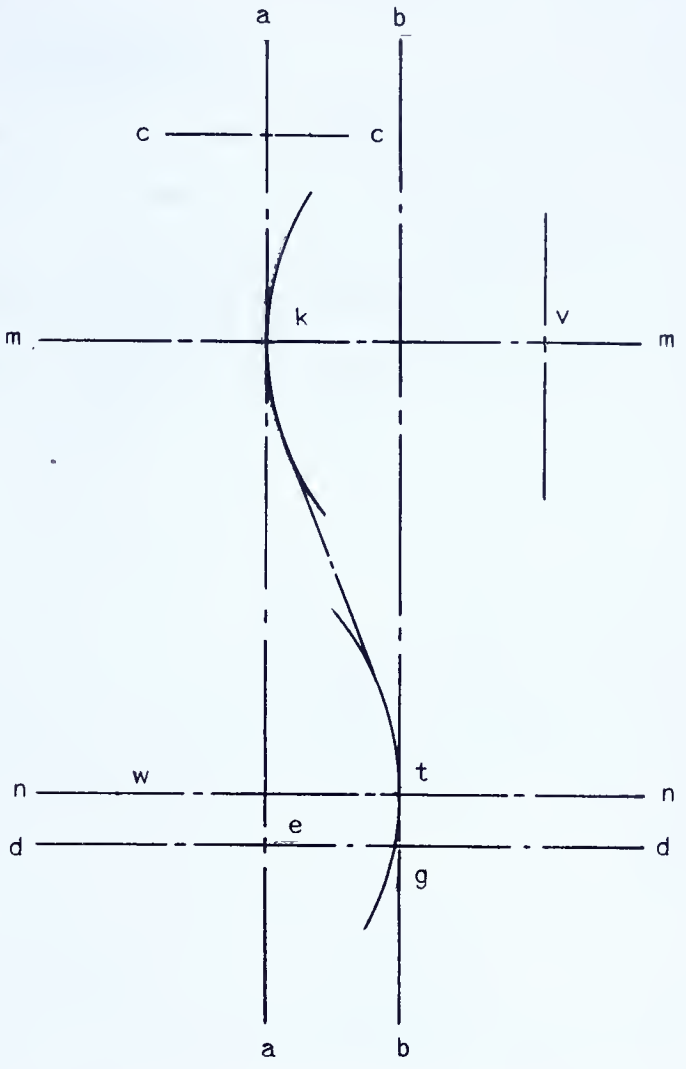


FIG. 291 — *Center Line Layout of Fig.* 290

12. Strike a square line through point *t* and label this line *n-n*.

13. Measure the bend radius 2′ 6″ from *t* along this line and mark this point *w*.

14. Strike an arc through *t*, using the trammels or soapstone and string, and use *w* as the center.

15. Place the straightedge and scribe a line tangent to the two arcs. The tangent line must meet the arcs "fair".

The layout for the center line of the pipe is now completed. The correct offset and the correct distance between flanges is now given. The template may now easily be bent over the layout.

QUESTIONS

1. Why is a chalk line used to strike long straight lines?
2. What value is there in showing the ends of the pipe on the layout?
3. What is meant by "erecting a perpendicular"?
4. How are the two curves of the offset joined on the layout?

JOB SHEET NO. 3
TO MAKE THE TEMPLATE SHOWN IN FIG. 292

General Information

There is a compound bend in this template. The position of the template pipe in the plan view (Fig. 292) is revolved 90° in the elevation. Compound bend means that the template pipe is bent two ways. The first bends are similar to the bends shown in the plan view. The second bends are made at right angles to the first bends. The positions of the template pipe and the relationships of the bends will be more clearly understood as the procedure for bending the template is followed.

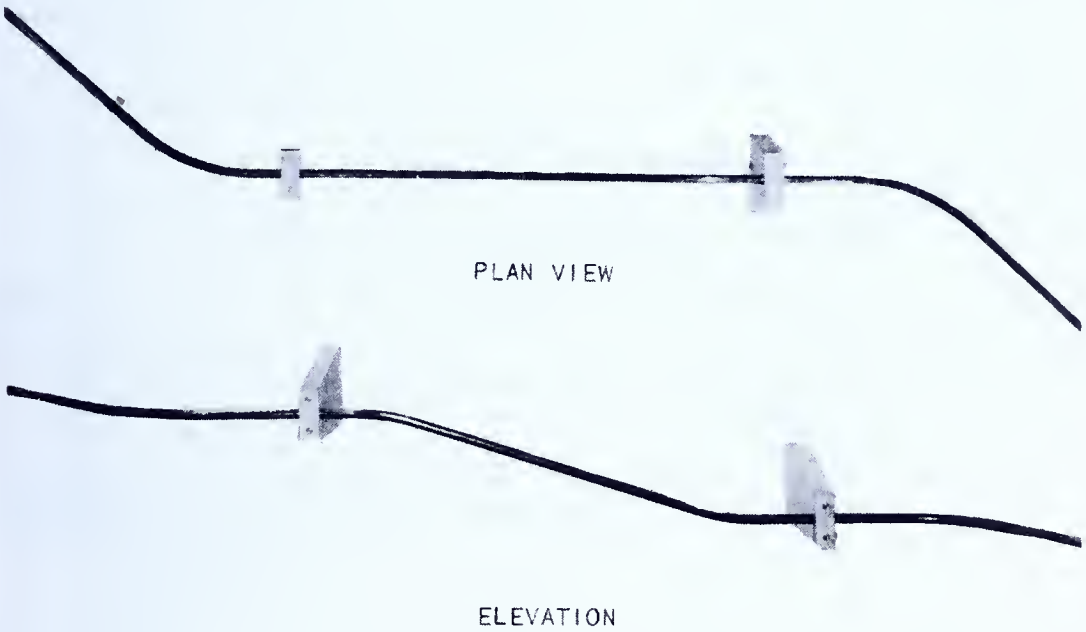


Fig. 292 — *Two Views of Template Pipe*

Tools	Materials
1. Chalk line	Chalk
2. Straightedge	Soapstone
3. Trammels	
4. Folding rule	

Procedure

1. Sweep clean a section of the shop floor approximately 14′ long and 6′ wide.
2. Use a chalk line, and lay down three lines close to one edge, parallel to each other, and 12″ apart the full length of the cleared space. Fig. 293.

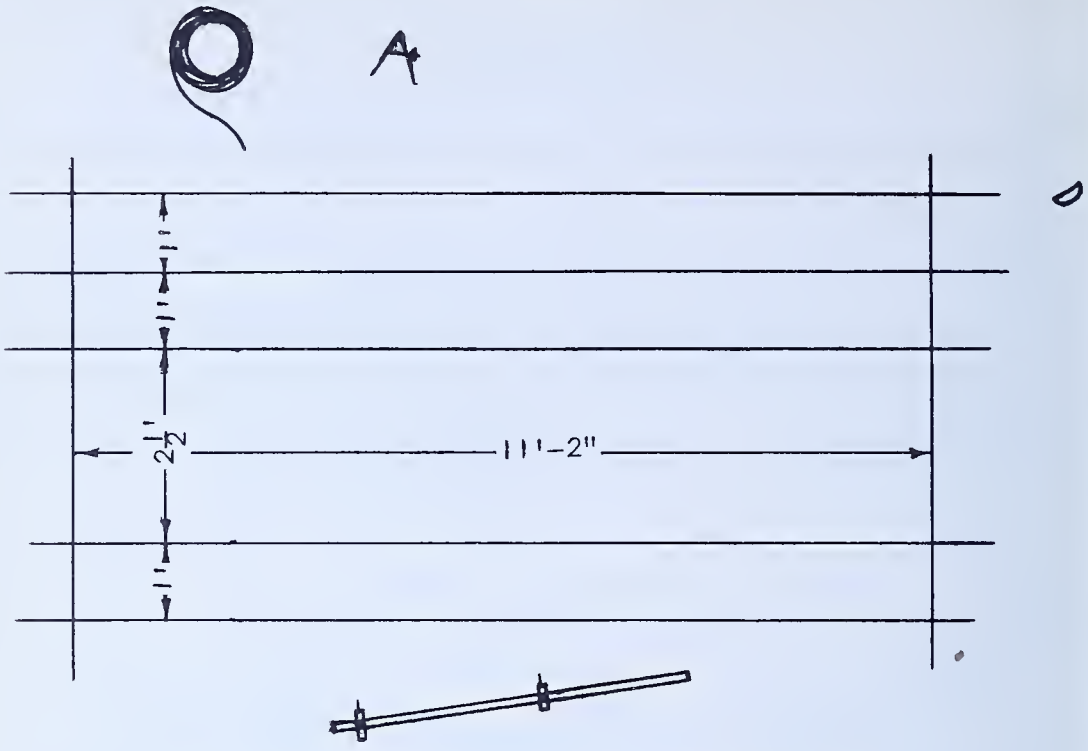


FIG. 293 — *Layout of Center Lines on Shop Floor*

3. Lay down two other parallel lines 12″ apart, and about two and one-half feet from the last chalk line.
4. Lay down a line perpendicular to the lines previously made and crossing all of them, close to one end.
5. By scaling the blueprint it is found that the pipe from end to end is to be 11′ 2″ long. Mark off this distance from the perpendicular line along one of the long lines.

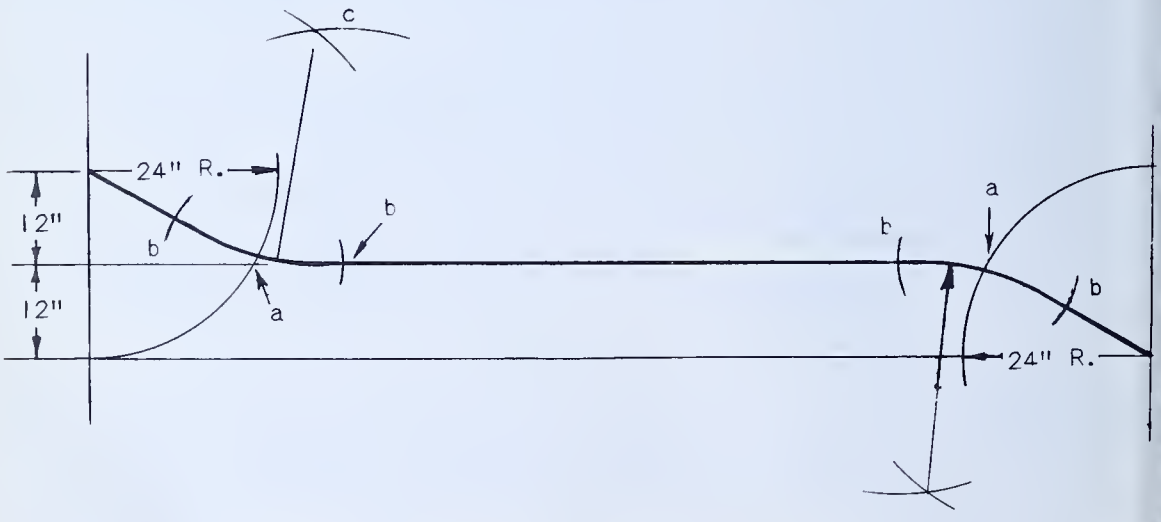


FIG. 294 — *Plan View of Center Line Layout*

6. Lay down a line perpendicular to the long lines at this point.

   These lines represent the limits of the extent of the pipe.

7. Set the trammels to 24″ and scribe the arcs from both ends as in Fig. 294.

   By scaling the plan view of the blueprint it is found that there is to be a 12″ roll at both ends of the pipe and that the measurement from the end to the center of the bend is 24″.

8. Trace a line, using a straightedge and soapstone, from both ends of the pipe to the points where the arcs cut the central line at *a*, Fig. 294.

9. Set the trammels to 12″. Then by placing one point on *a* at both ends, scribe arcs as shown at *b*, Fig. 294.

10. Set the trammels to 30″ (the recommended bend radius for 6″ pipe) and scribe the arcs at *c* from points *b*.

11. Using the same setting on the trammels, place one point on this intersection *c* and scribe the arcs for the bends.

    This completes the plan view.

12. When the elevation Fig. 295 is scaled on the blueprint it is found that there is a 12″ offset starting 4′ from both ends of the pipe. Mark off these distances from the ends, one on the upper line and one on the lower line.

13. Connect these two points, using a straightedge and soapstone.

14. Scribe the arcs for the bends.

    This completes the layout for the elevation view of the pipe.

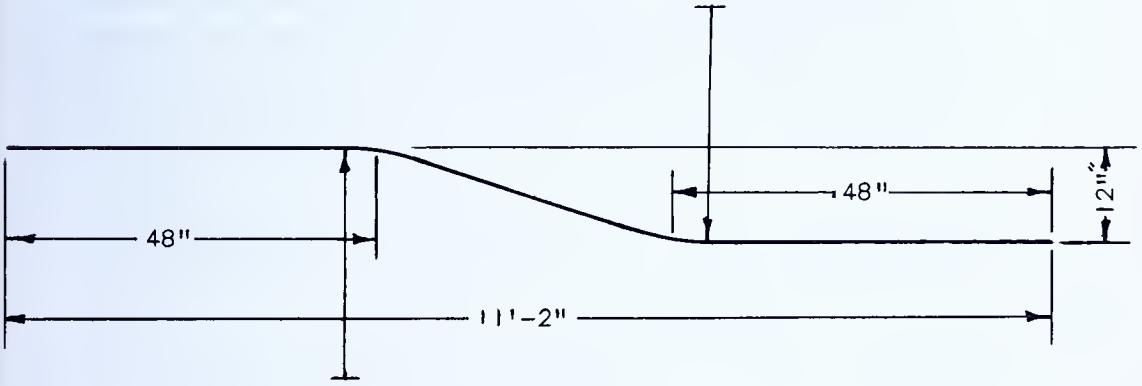


FIG. 295 — *Elevation of Center Line Layout*

15. Lay the template pipe even with the left end of the plan view and mark the position of the start of the bend on the pipe.

16. Pick up the template pipe and make the bend.

    Lay the template pipe on the layout to see that it conforms to the layout.

17. Hold the template over the elevation so that the bent end points down and is even with the left end of the elevation layout.
18. Mark the start of the next bend on the template pipe.
19. Carefully bend the pipe until it conforms to the layout.
    This bend is made at right angles to the one previously made.
20. Check the bends made with the two views of the layout.
21. Hold the pipe over the elevation, Fig. 292, and mark the position for the start of the next bend.
22. Pick up the pipe and make the next bend.
23. Hold the pipe over the plan view, Fig. 294, and sight down on the pipe to see if it conforms with the layout.
24. If the pipe conforms with the layout, mark the position of the last bend on the pipe.
25. Pick up the pipe and make the last bend.
26. Sight down upon the template to check it with the layout. If it conforms to both layouts, the template is ready to use in bending the pipe. Cut off the short length of template that will extend over the end of the layout and compute the length of pipe needed.

QUESTIONS

1. **Why is it necessary to examine more than one view of the pipe when a layout of a pipe is to be made from a blueprint?**
2. **Why is a rough dimensioned sketch made before the layout is started?**
3. **What is meant by scribing an arc?**
4. **Explain the meaning of the terms "elevation" and "plan" as used on blueprints.**
5. **Why is it necessary to check the template with the layout after all the bends are made?**

JOB SHEET NO. 4
TO MAKE A PIPE TEMPLATE

General Information

When a template is to be made, several things have to be considered before actual work is started. The advisability of making a layout must be considered. In some instances less difficulty would be encountered if the template were bent on the ship to conform to conditions there. In other cases a layout on the shop floor would provide the best solution to the construction of a template. Often it is not necessary to make a template for the full length of pipe. A template just covering the bends may be sufficient.

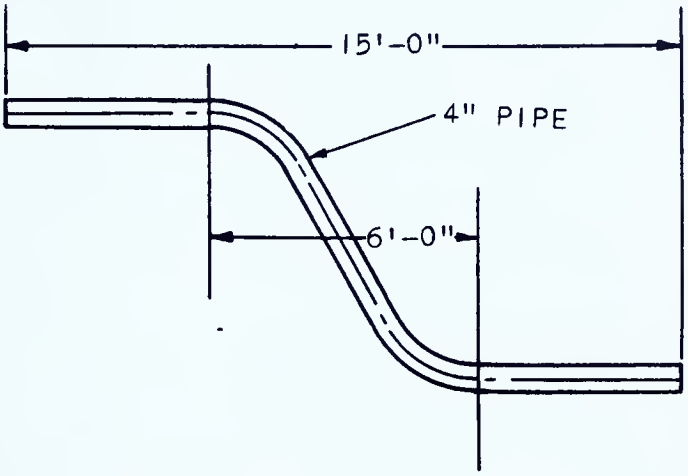


Fig. 296 — *Layout for Which Template Is Required*

Selecting the Template Pipe

The ultimate length of the template must be considered in order to select the proper size of pipe. If a 16′ installation were to be made, ½″ template pipe would have to be used in order to make the template rigid enough. For a 4′ section the use of ½″ pipe would be wasteful and ¼″ template pipe would be used. For a 10′ or 12′ installation, ⅜″ template pipe would be satisfactory. If a full length template is to be made, the estimated length may be obtained by scaling the blueprint.

Bending the Template

Procedure Used With a Layout

1. Select a piece of pipe the proper diameter and approximate length for the job. Measure the length of the pipe and record for future reference.
2. Place one end of the template pipe even with the one end of the layout on the floor. See Fig. 297.

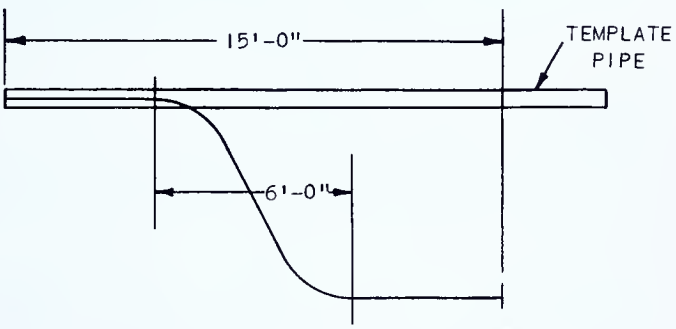


Fig. 297 — *Preparing to Bend a Template Pipe Over the Layout*

3. Mark on the pipe with soapstone the point where the radius starts.
4. Pick up the pipe in both hands and start the bend at the mark on the pipe by bending over the knee.
5. Move the pipe around a bit and bend a little farther. See Fig. 298.
6. Continue bending a little at a time until the pipe conforms with the layout on the floor.
7. Place the pipe on the floor and mark off the point where the next bend starts.
8. Repeat the process by bending a little at a time until the correct curve is obtained.

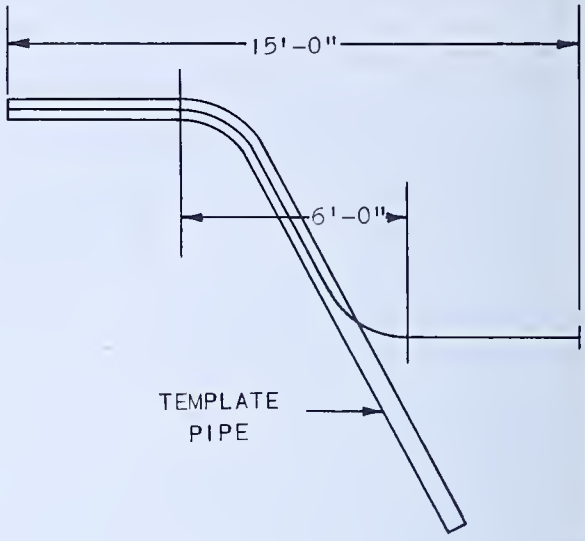


FIG. 298 — *Bending the Template Pipe*

9. Check with the layout on the floor. The template may not lie flat on the floor after bending. This condition may be remedied by pounding the high spots of the template with a hammer or mallet.

   CAUTION — If the template has to be flattened with a hammer always be sure to check with the layout, for pounding may have straightened some of the bends.
10. If the end of the template is short of, or longer than, the required distance on the layout, measure this distance and subtract or add to the original length in order to get the correct size of pipe for the job. If the template is too long, cut it to the proper length. The template is now ready to use.

BENDING THE TEMPLATE ABOARD SHIP

If a situation arises where the blueprint does not furnish sufficient information concerning surrounding objects the template pipe must be bent around the obstacles.

PROCEDURE

1. Select a piece of pipe the proper thickness and approximate length for the job.
2. Take this pipe and bend it to the required form.
   The bends are made by hand.

   CAUTION — The radii must not exceed the recommended bend radius (5 times the nominal diameter of the pipe) for the size of pipe that is to be installed. Sometimes conditions necessitate the making of shorter bends. In this case the pipe will have to be packed with sand and heated to bend it properly.

3. Fit the template into position. Either have someone hold the template in position or wire it into place.

4. Check carefully to see that the pipe to be installed will clear all the nearby objects. It is well to allow some clearance for the pipe diameter.

5. At each end of the template check the distance the template may fall short of, or extend beyond, the flange faces of the connecting pipes. Record these measurements; they will have to be used for computing the length of pipe needed.

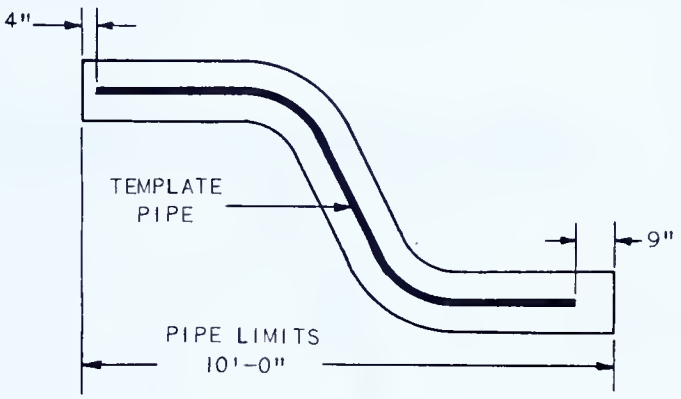


FIG. 299 — *Template Pipe Longer Than Layout*

COMPUTING THE LENGTH OF PIPE NEEDED WHEN A LAYOUT IS USED

The correct length of template pipe is not always obtainable from the blueprint and so the proper length of pipe actually needed must be computed after the template has been bent.

PROCEDURE

1. Lay the template over the layout on the floor.

2. Measure the amount of pipe extending beyond or falling short of the pipe limits on the layout.

3. a. If the original pipe is 14′ 9″ long before it is bent and the amount extending over the limits on the layout totals 16″ then the length of pipe needed is 14′ or 168″ — 16″ = 152″ or 12′ 8″, the length of pipe required.

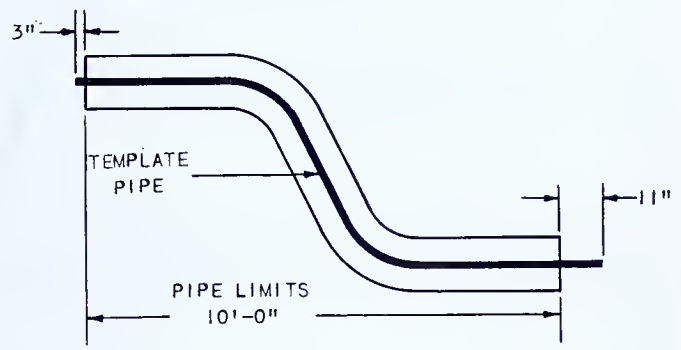


FIG. 300 — *Template Pipe Shorter Than Layout*

b. If the template is 6″ short on one end and 10″ short on the other end the length of pipe needed is 14′ + 6″ + 10″ or 168″ +6″ + 10″ = 184″; 184″ ÷ 12 = 15′ 4″.

Computing the Length of Pipe Needed When the Template is Made Aboard Ship

Procedure

1. Select a long straight-edged piece of board and place it upon a work bench.

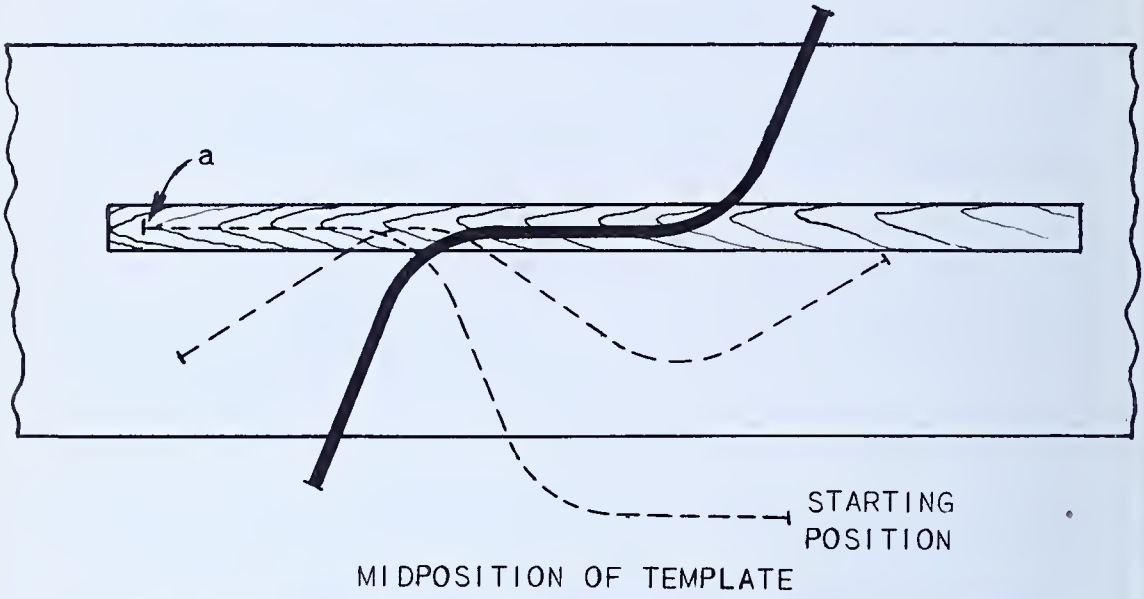


Fig. 301 — *Finding Length of Pipe Needed by Measuring Template*

2. Place the template on the bench with one end even with mark *a* near the end of the board.
3. Holding the template tightly against the board, roll the bend along the board. Care must be taken so that the template does not slip on the board.

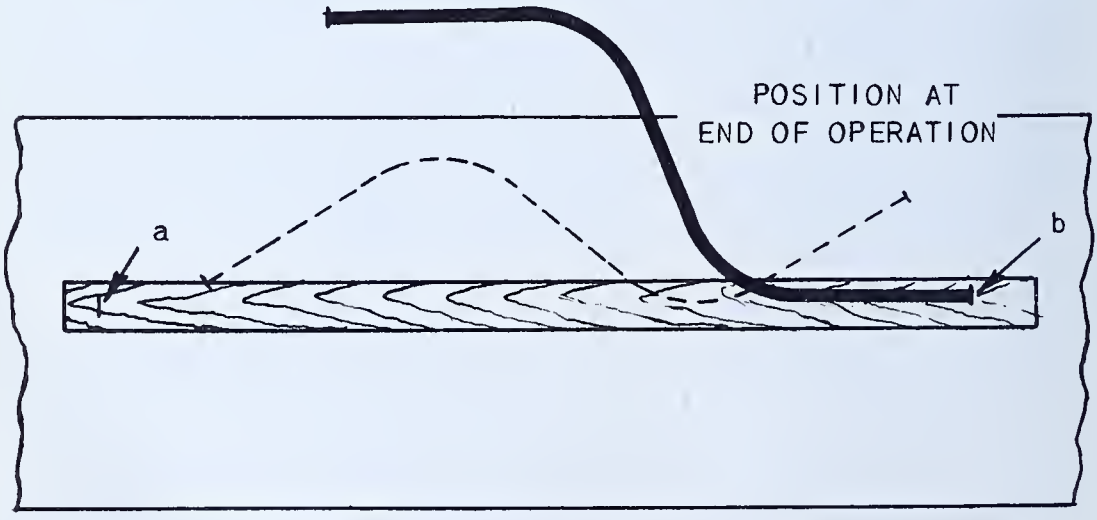


Fig. 302 — *Length of Pipe Required*

4. Continue rolling the template until the opposite end of the template rests against the board. Mark this point.
5. Knowing the amount that the template had been short of or longer than the required distance, add or subtract this amount to that on the board and mark this point *b*.
6. Measure the distance from *b* to *a* where the template end had rested. This will be the length of pipe needed.

Bracing a Template

The necessity of bracing a template occurs only in special cases where the template would be too long to be rigid and would "spring" out of shape. Usually only a partial template is made and only the bends are covered by the template. This cannot be done, however, where the bends are too large or too far apart. If this situation arises, the bends may be stiffened by having a straight piece of template welded across the bends as in Fig. 303. If a template is stiffened in this manner there is danger of warping or twisting the pipe by the welding heat. A template that has been stiffened should always be checked with the layout before it is used.

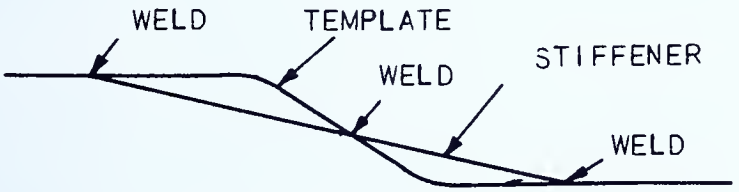


Fig. 303 — *Braced Template*

QUESTIONS

1. **Why are not all templates made from layouts?**
2. **Why should ½″ pipe not be used to make a template 4′ long?**
3. **Why is the template pipe marked before it is bent?**
4. **How is the correct bend radius obtained on the template?**
5. **What advantage is there in measuring the template pipe before it is bent to shape?**
6. **Why must template pipe sometimes be bent aboard ship?**
7. **Explain how the length of the template is obtained after it has been bent.**

JOB SHEET NO. 5
TO MAKE A LAYOUT TEMPLATE FOR A MITER JOINT

General Information

Sometimes it is necessary, aboard ship, to install a pipe section similar to the one shown in Fig. 304. There may be insufficient space between the bottom flange and the

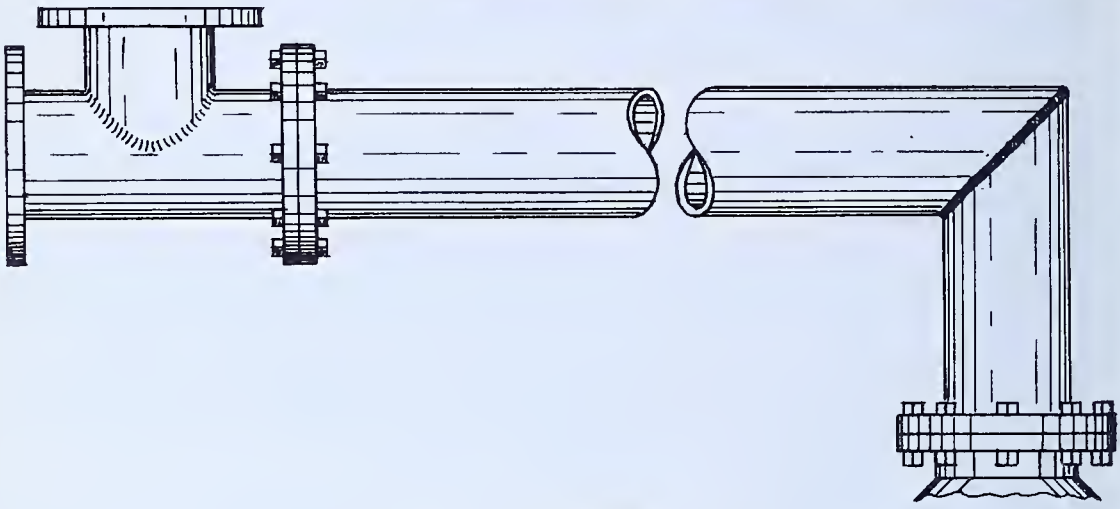


Fig. 304 — *Miter-Weld Joint*

horizontal pipe to permit a bend. The recommended bend radius is 5 times the diameter of the pipe. To solve a problem such as this, the pipe ends are cut off at a 45° angle and are welded together. For small pipes they could be cut off in a power hacksaw but for large pipes the ends have to be burned off with a torch. One of the simplest ways to mark the pipe for the burner is to make a template and mark along the edge of the template. The procedure for making such a template is given below.

Procedure

1. Make a full sized two-view layout of the end of one of the pipes as in Fig. 305.

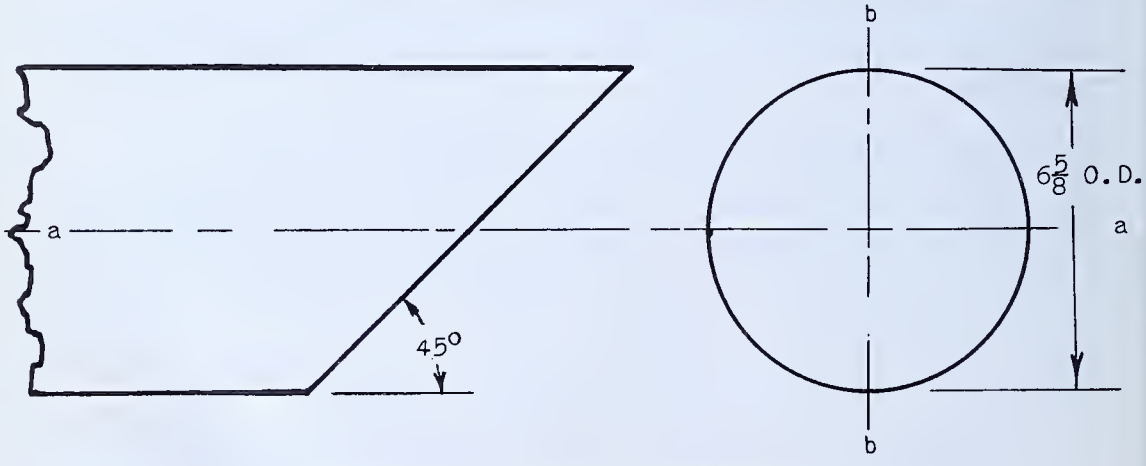


Fig. 305 — *Layout of Pipe End*

2. Divide the end view into 12 equal spaces.

   Use the radius of the circle and starting at the horizontal centerline *a* step off 6 equal spaces on the circle. Bisect each of the spaces by stepping off 6 equal spaces from the vertical center line *b*. This will give the twelve equal spaces.

3. Project lines parallel to the center line from these points on the circle through the profile view. Fig. 306.

4. Erect a perpendicular to both sides of the centerline at a point about 9″ from the nearest edge of the end as line *x*-*x* in Fig. 306.

5. Number the lines from shortest to longest *0* through to 6.

   The layout will now furnish sufficient information to construct the template.

6. Cut out a piece of template paper 15″ wide and at least 21″ long.

   The template length will be the same as the circumference of the pipe. For a 6″ pipe the circumference would be 6.625 x 3.1416 or 20.813 or approximately 20 13/16″. Allowance must be made for trimming the edge.

7. Using a straightedge and a pencil or scriber draw a line across the template paper about 1″ from the bottom.

8. Lay off a distance *0* to *0* equal to the circumference of the O.D. of the pipe on the horizontal line.

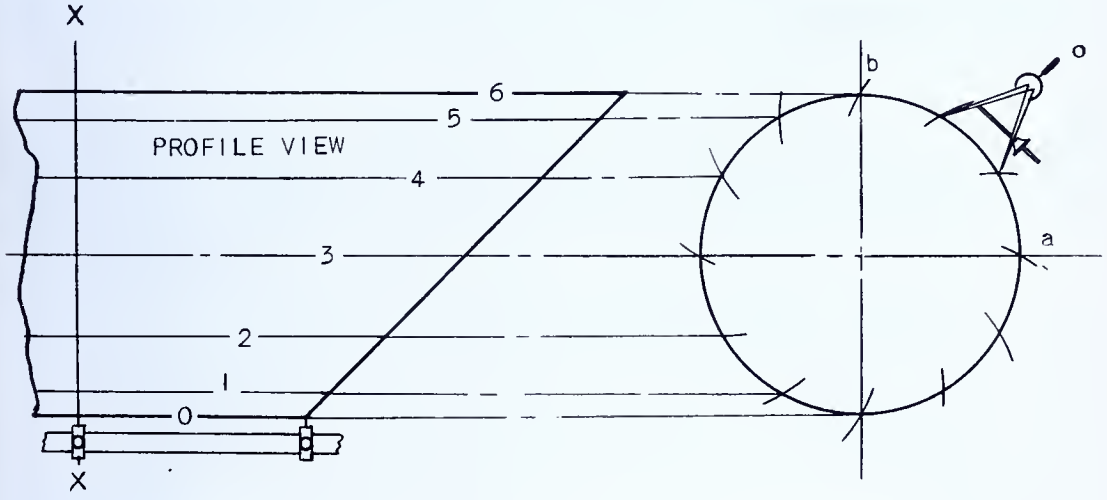


FIG. 306 — *Obtaining Measurements from the Layout*

9. Divide the distance *0* to *0* into 12 equal spaces.

10. Place a square even with the bottom line on the template paper and draw perpendiculars to each of the 13 marks on the line. Fig. 307. The template paper is now ready to be marked off for cutting.

11. Number each of the perpendiculars from *0* to *6* and then in reverse to *0* so that no mistake may be made.

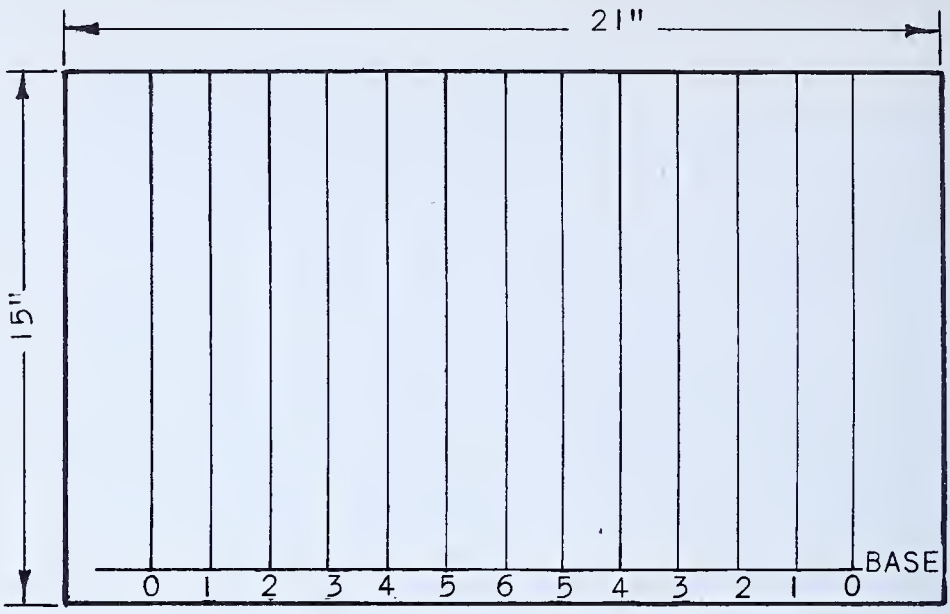


FIG. 307 — *Laying Out Template Paper*

12. Set the trammels from the working line *x-x* to the end of line *0* (see Fig. 306) and transfer this distance to line *0* on template paper.

    Mark off this distance from the base line on both *0* lines.

13. Reset the trammels to the distance of line *1* on the layout and transfer it to both lines *1* on the template paper.

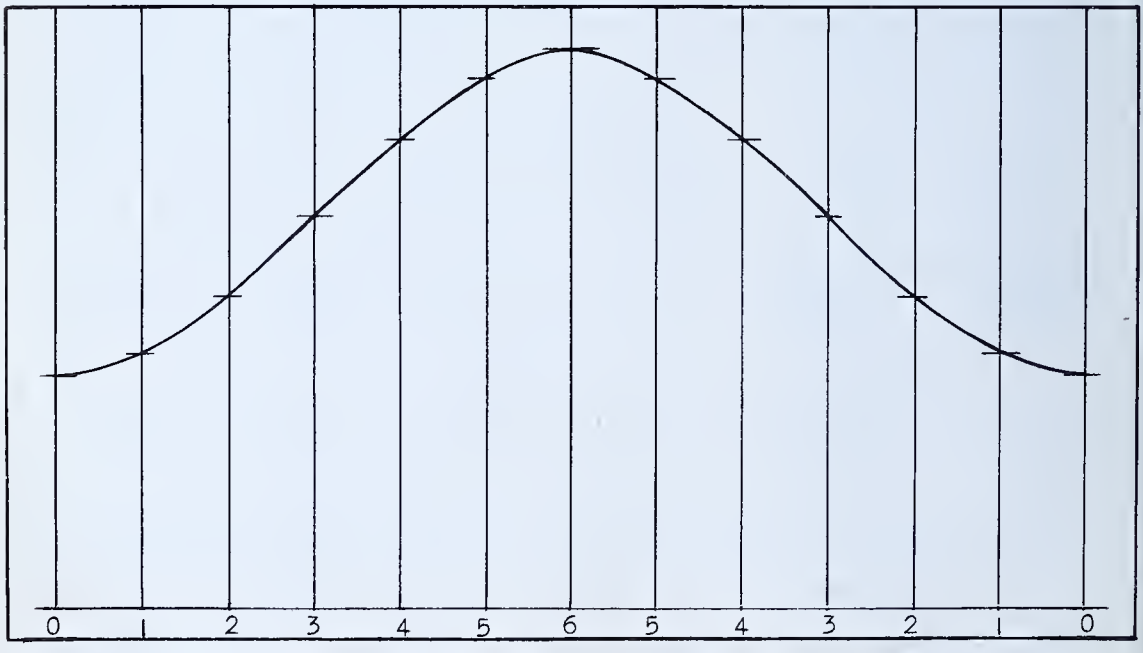


FIG. 308 — *Laying Lengths on Template Paper*

14. Transfer the length of all the lines on the layout to the corresponding lines on template paper. See Fig. 308.

15. With a pencil connect all the points made on the template paper to form a smooth, curved line.

16. Cut out the template along the base line, the two *O* lines, and along the curved line. See Fig. 309.

17. Wrap the template around the pipe with the two *0* lines alongside each other.

By using soapstone or pencil to trace the curved edge of the template, the position for the cut on the pipe can be marked. After the pipe is cut along the line thus made, the two ends of pipe are fitted together for welding.

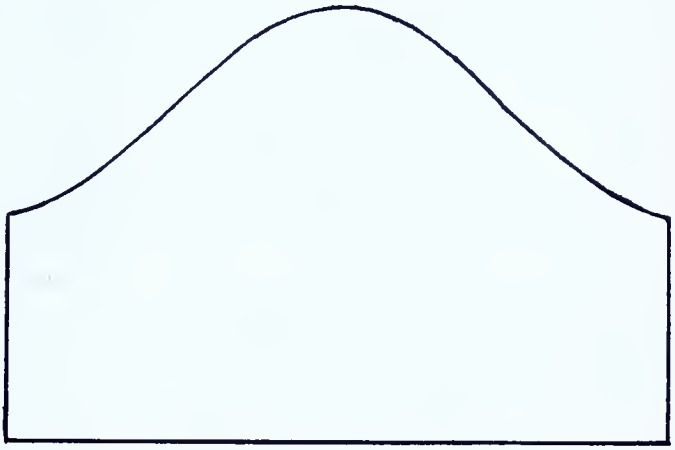


FIG. 309 — *Completed Template*

QUESTIONS

1. **Why are miter-weld joints sometimes used?**
2. **Why are the lines numbered on the layout and on the template?**
3. **Why must the circumference of the pipe be obtained?**
4. **How are measurements transferred from the layout to the template paper?**
5. **How is the curve on the template paper transferred to the pipe?**
6. **Is it necessary to mark the curve on both pipes to obtain an accurate fit? Why?**

JOB SHEET NO. 6
TO MAKE A LAYOUT TEMPLATE FOR A SADDLE-WELD JOINT

General Information

The pipefitter encounters many jobs where a tee, a lateral, or an elbow cannot be used, because there is insufficient room to accommodate a fitting. In such cases a saddle-weld joint is made and the branch pipe is welded into place. A typical saddle-weld joint is shown in Fig. 310.

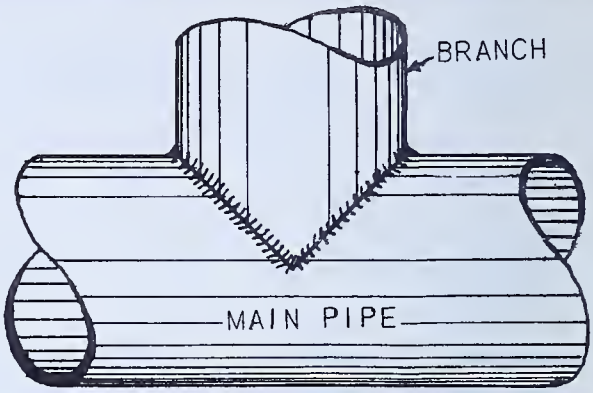


Fig. 310 — *Saddle-Weld Joint*

The opening of the pipe and the end of the branch are cut or burned to fit together. The end of the branch is first cut to the correct shape. It is then placed in position on the pipe and held firmly while a line is scribed around the shape of the branch onto the outside of the main pipe. See Fig. 311. The outside thus scribed guides the burner when cutting the opening in the pipe.

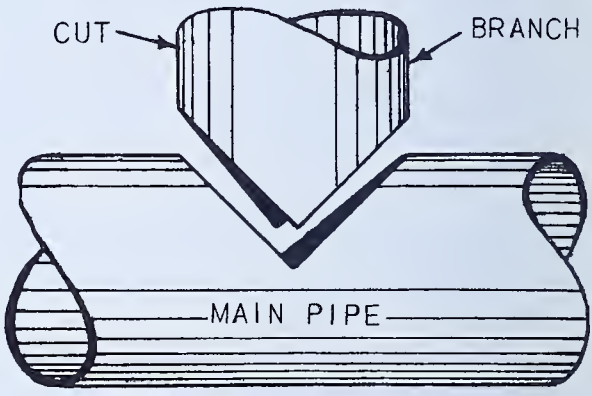


Fig. 311 — *Joint Cut to Fit*

It is comparatively easy to cut a small pipe and mitre the joint because the cut is a straight line. To cut a large pipe for a saddle-weld joint, a template is required to lay out on the pipe the shape to which it must be cut.

Developing a Curve on a Template

If the branch pipe shown in Fig. 311 were cut along the side indicated by the arrow and laid out flat it would look something like Fig. 312. The over-all length of the piece is the same as the outside circumference of the pipe. The distances marked *d* are all the same, just one-quarter of the circumference and one-quarter of the over-all length.

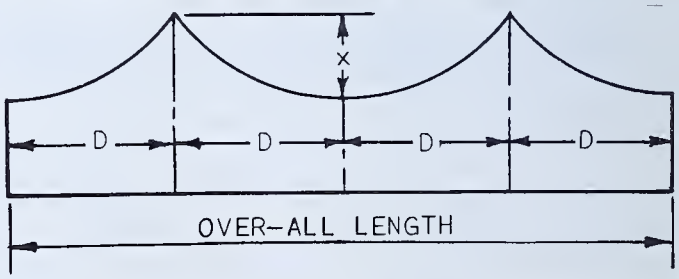


Fig. 312 — *Branch Cut and Laid Flat*

The two pointed sections are just one-half of the circumfer-

ence apart and the height x is the same as the depth of the notch in the pipe in Fig. 311. To develop the curved lines shown in Fig. 312 for a certain diameter pipe, the mechanic must lay out a two-view arrangement of the pipe and mark off the points through which a curved line is scribed. The template is then cut out on the scribed line and wrapped around the pipe. The pipe is marked with soapstone to the template outline, the line is center-punch marked, and the pipe is burned off to the line. The work for developing a template for a 90° saddle-weld joint in a 12″ pipe may be summarized as follows:

TOOLS AND EQUIPMENT

1. 6′ steel tape or folding rule
2. 10″ dividers
3. 4′ straightedge
4. Scriber
5. Trammels
6. Tin snips

MATERIALS

Template paper
Soapstone

PROCEDURE

1. Make a two-view layout of the pipe branch as shown in Fig. 313. The outside diameter of a 12″ pipe is 12¾″.

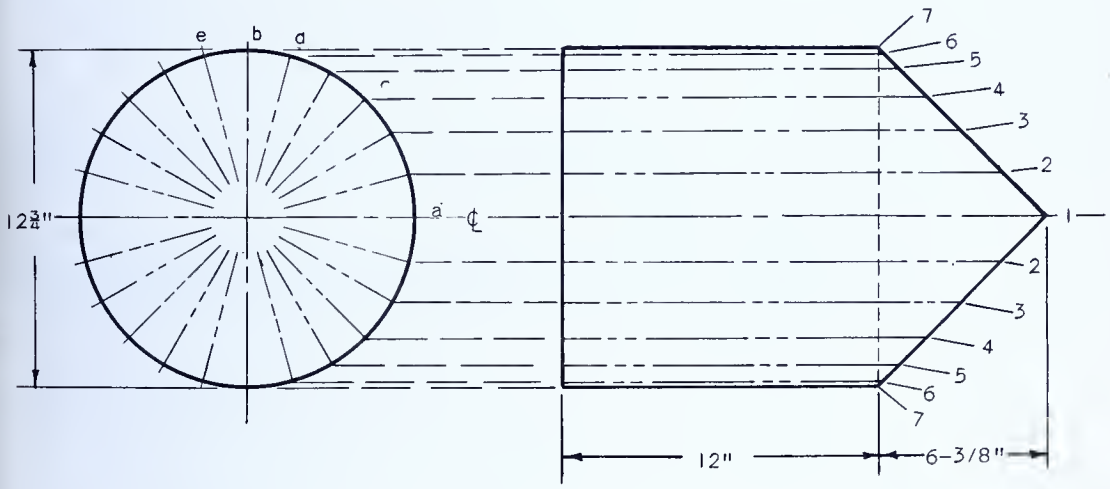


FIG. 313 — *Two-View Layout of Branch Divided into 24 Equal Spaces*

2. Using the radius of the circle, start at the intersection of the vertical center line and the circle and step off the radius distance around the circle.

   This will divide the circle into six equal spaces.

3. Bisect one of these spaces and again step off the radius around the circle.

   This will divide the circle into 12 equal parts.

4. Bisect one of the remaining larger spaces and again step off the radius.

   The circle will now be divided into 24 equal spaces. It is not always necessary to have 24 spaces but the more spaces there are, the more accurate the layout will be.

5. Project the points of division parallel to the center line through the side view of the branch as shown in Fig. 313.

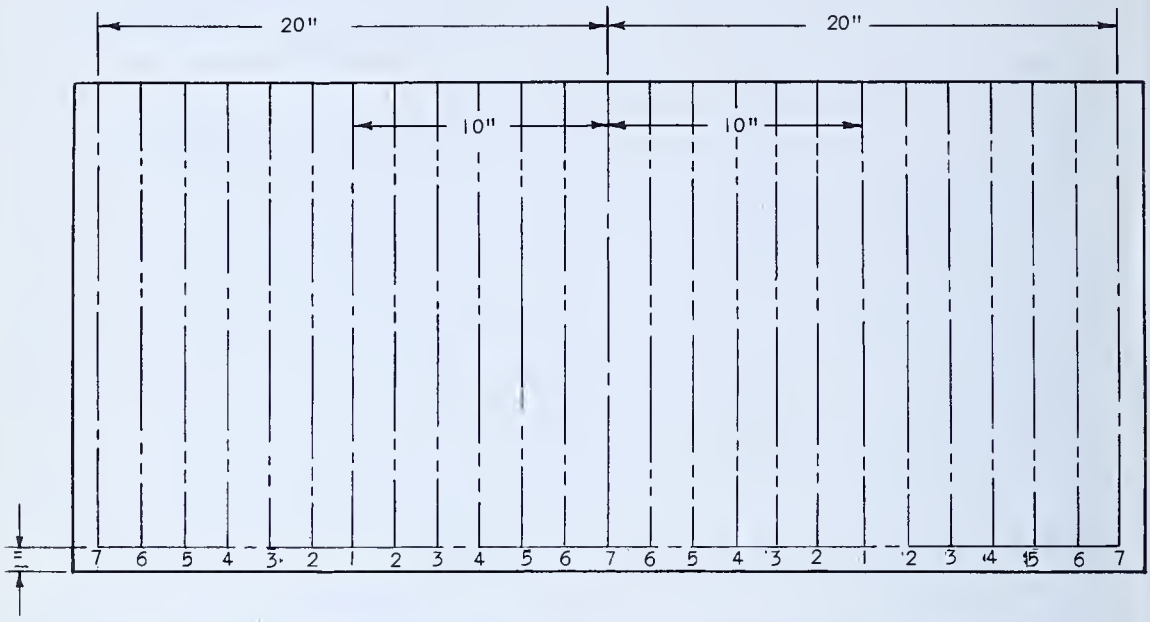


FIG. 314 — *Template Paper Ready to be Marked for the Curve*

6. Number the lines as shown in Fig. 313.

   NOTE: The distance 12″ is not particular as any distance may be selected. The distance should be long enough so that the template will be rigid. The distance 6⅜″ is half the O.D. of a 12″ pipe.

7. Cut off a piece of template paper 42″ long and 20″ wide. The circumference of the pipe is 12¾″ x 3.1416 = 40.05 or 40″ approximately. This allows about 1″ on either side for cutting.

8. Scribe a line across the full length of the template paper about one inch from the bottom.

9. Using a steel square, erect a perpendicular, about one inch in from the end, to the base line.

10. Lay off a distance 7-7-7, (equal to the circumference of the O.D. of a 12″ pipe), on the horizontal line scribed in Step 8, beginning at the base of the perpendicular erected in Step 9.

11. Divide the distance laid off in Step 10 into 24 equal spaces.

12. Number the points from 7 to 1 and in reverse back to 7 again and then repeat. The last point and the first point should be No. 7 lines.

13. From each of the 24 points thus made, erect perpendiculars to the base line (lines parallel to the first perpendicular).

    The template paper is now prepared to receive the measurements for marking off the curves. See Fig. 314.

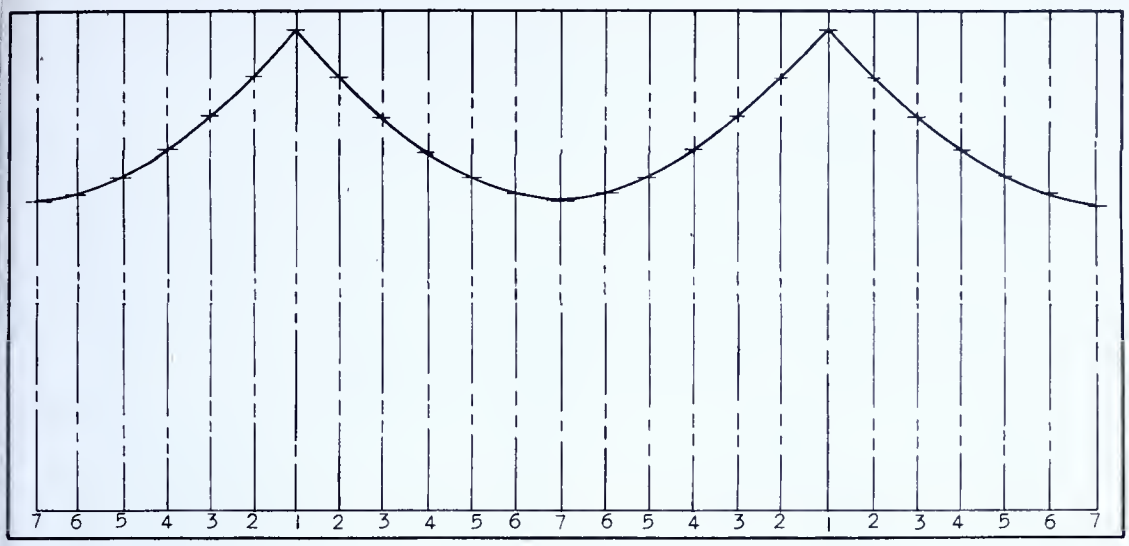


FIG. 315 — *Curve Marked on the Template Paper*

14. Refer to the layout (Fig. 313) and set the trammels on the length of No. 7 line.

15. Transfer this distance to the No. 7 lines on the template paper.

    Reset the trammels to the length of No. 6 line on the layout and transfer it to the No. 6 lines on the template paper.

16. Transfer the length of all the lines in a like manner to the template paper. Fig. 315.

17. Use a pencil to connect the points marked on the template paper. Light pencil line should be used until the curves blend smoothly as shown in Fig. 316.

18. Cut the template paper along the curved lines, the base line, and along the end No. 7 lines. (The sharp points at the junction of the curved lines (Fig. 316) should be rounded off.)

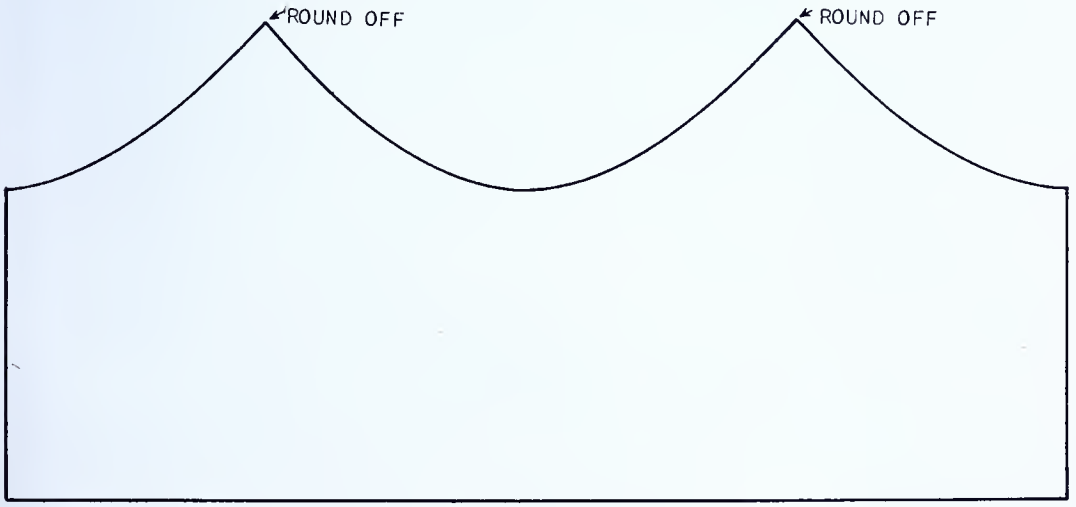


FIG. 316 — *The Finished Template*

19. Wrap the template around the branch pipe so the No. 7 lines will come together evenly and with soapstone mark along the edge of the template.
20. Mark the soapstone line with a center punch at 2″ intervals.
21. Have the pipe burned off on the center-punched line.
22. Smooth the burned edges of the pipe.
23. Set the branch pipe on the main pipe as shown in Fig. 310.
24. Check carefully the alignment of the branch.
25. Mark with soapstone on the main pipe all around the branch.
26. Center-punch mark the soapstone line at 2″ intervals and ⅜″ in from the soapstone line.

    This will provide surface for the branch to rest upon and will prevent the branch pipe from extending down into the main pipe.
27. Have the opening burned in the main pipe.

    The branch pipe can now be set on the main pipe and tack welded in place. If the alignment is found to be correct, have the welders finish the job.

QUESTIONS

1. **What is meant by the phrase "saddle-weld joint"?**
2. **Why is a template made when a saddle-weld joint is necessary?**
3. **State the first step to be taken when about to make a saddle-weld joint template.**
4. **Why is it necessary to make a two-view layout of the branch pipe before laying out the template?**
5. **Into how many equal spaces should the pipe circumference be divided?**
6. **What is the advantage of having a large number of equal spacings?**
7. **How is the template laid off in relation to the two-view layout?**
8. **From where are the measurements obtained for the intersections on the perpendicular lines in Fig. 315?**
9. **Explain the method of scribing the curved line on the template.**
10. **How is the curved line transferred from the template to the branch pipe?**

JOB SHEET NO. 7
TO MAKE A LAYOUT TEMPLATE FOR A 60° SADDLE-WELD JOINT

General Information

Sometimes the ship pipefitter encounters cases where ordinary threaded fittings such as tees, elbows, or wyes cannot be used because of limited space A situation is

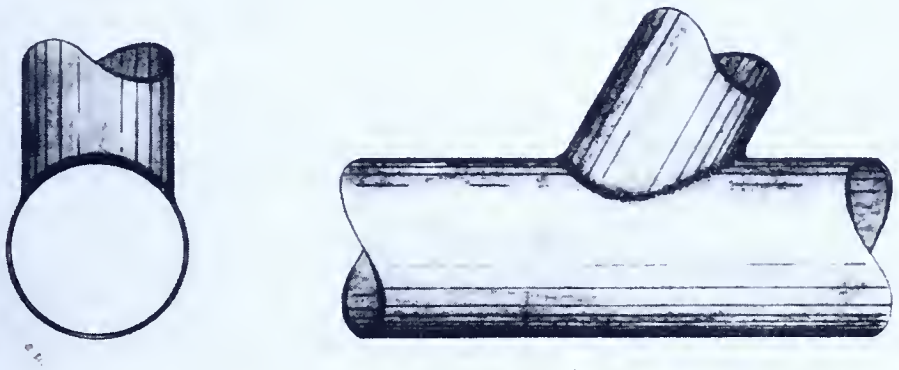


Fig. 317 — *A 60° Saddle-welded Branch*

encountered where a branch pipe enters a main at an angle and the branch is smaller than the main pipe. A problem such as this can be solved efficiently only by the construction and use of a template.

In order to prepare the end of the branch and the opening in the main pipe to be burned or cut to the correct shape, it is necessary to prepare a template for marking the position of the cut on the branch pipe end. The prepared branch end can then be fitted over the main pipe (See Fig. 318) and the position for the cut on the main pipe can be found by scribing a line around the fitted branch end. This cutline guides the burner when he cuts the opening in the main.

Tools and Equipment

1. 6′ steel tape
2. 10″ or 12″ dividers
3. 3″ or 4″ straightedge
4. Scriber
5. Trammels
6. Tin snips

Materials

Soapstone

Template paper

Developing the Template

In this case a 10″ branch pipe enters a 12″ main pipe at an angle of 60°. If the branch pipe were cut along the top at *a*, Fig. 318, and flattened out it would look

something like Fig. 319. The length or height *H* is the greatest length of 10″ pipe needed. The length *M* is the length of pipe along the inside of the 60° angle. The template that will be needed to prepare the pipe for cutting it to shape may be compared to this flattened piece of pipe. The template is easily prepared and wrapped around the pipe. By marking along the edge of the template and then center punching along this line, the position for burning the pipe is plainly marked. In this case we have a 10″ branch entering a 12″ main but the procedure that follows may be used for any sizes of pipe and any angle. The only difference will be in the drawings that are necessary and the dimensions used.

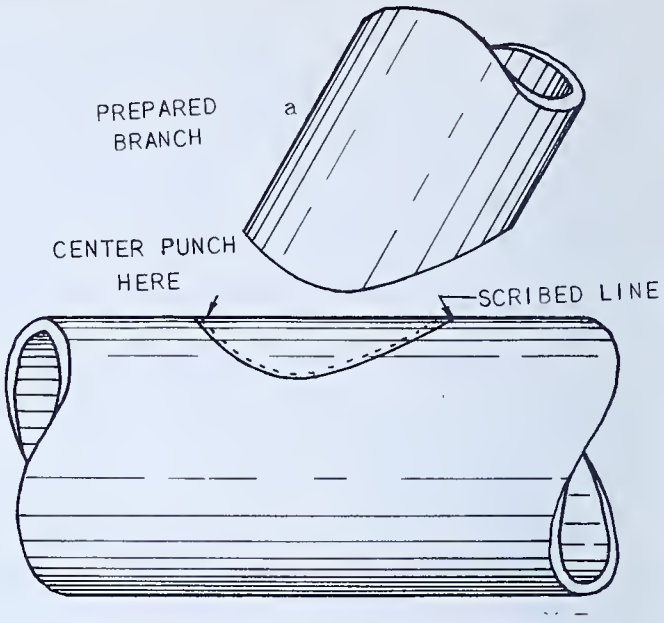


FIG. 318 — *Marking the Position of the Cut for the Opening in the Main Pipe*

PROCEDURE

1. Find the circumference of a 10″ pipe.
   a. The circumference of any pipe may be found by multiplying its outside diamater by 3.1416.
   b. The O.D. of a 10″ pipe is 10.75″.
   c. 10.75″ × 3.1416 = 33.87″ or approximately 34″.
2. Make a two view layout of the joint as shown in Fig. 320.
3. Make an end view of the branch pipe as shown in Fig. 320 and divide the view thus formed into 24 equal spaces as shown by the illustration.

   This may be accomplished by setting the scriber with the radius of the 10¾″ circle and stepping off this distance (5⅜″) around the circumference of the circle from the horizontal centerline. This will give 6 equal spaces. From the point where the vertical center line cuts the circle again

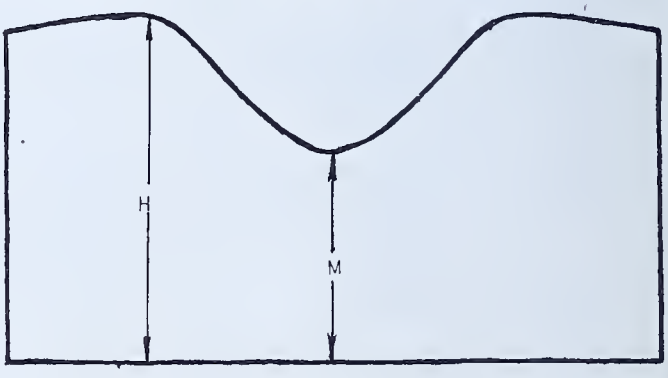


FIG. 319 — *Flattened Shape of Branch*

step off the 5⅜″ radius around the circle. This will divide the circle into 12 equal spaces. Bisect each of these spaces (*a*, Fig. 321) making 24. (An easier way of dividing the circle into 24 equal spaces may be used if a protractor is available. Mark off spaces every 15°. This will give 24 equal spaces.)

4. Project the points of division on the circle parallel to the center line until they meet the line formed by the joining pipes. The drawing is now prepared to give the dimensions needed for making the template.

5. Number the lines or divisions on the circle as illustrated.

It will be seen that lines 23-1, 22-2, 6-18, etc. are of the same length so that they are numbered on the template according to their values. Since there are only 12

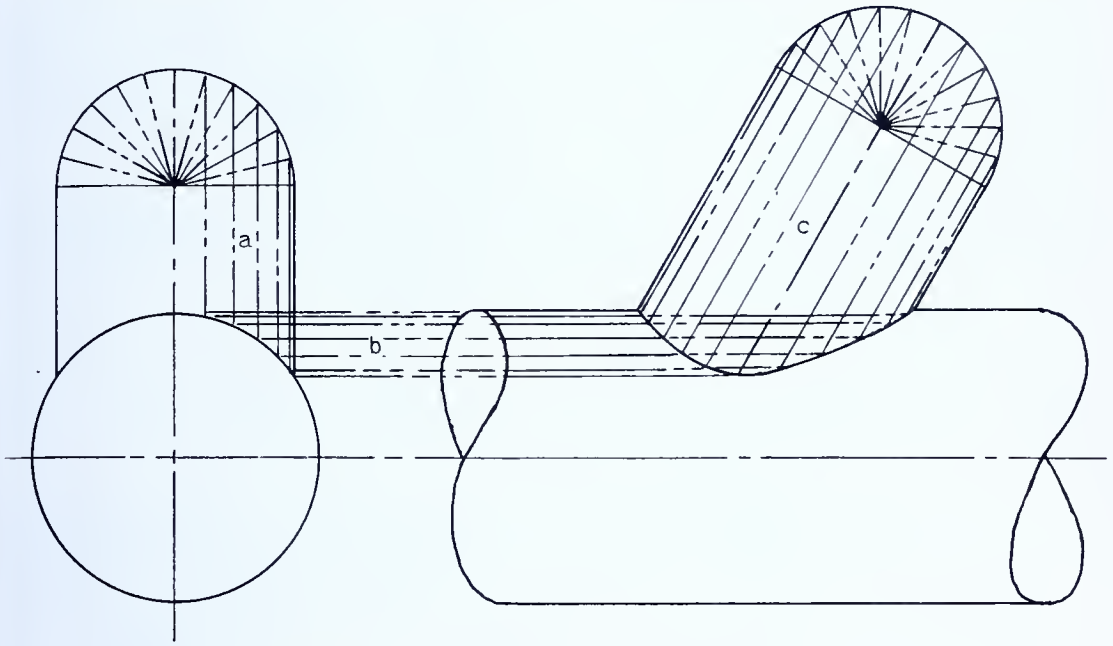


FIG. 320 — *Plotting the Curve for the Cut*

lines of unequal length, use numbers from 0 to 12 and then back to 0. This will give the complete template.

6. Since the circumference of a 10¾″ pipe is approximately 34″ and the template should be long enough to be sturdy, cut out a piece of template paper 36″ long and 18″ wide.

7. Using the straightedge, scribe a base line across the length of the paper about 1″ from the bottom edge. Fig. 322.

8. Erect a perpendicular center line (a line that forms a right angle) from the center of the base line.

9. Lay off half the length of the template or 17″ on each side of the perpendicular and erect perpendiculars at these points.

10. Divide these spaces into two, leaving four 8½″ spaces and erect perpendiculars at these points.

11. Divide each of these spaces into six equal spaces.

12. Scribe lines from these points parallel to the perpendiculars.

13. Number these lines 0 to 12, which is the center line, and then in reverse back to 0, Fig. 321.

14. From the working line *w* on Fig. 321 carefully set the trammels or dividers on

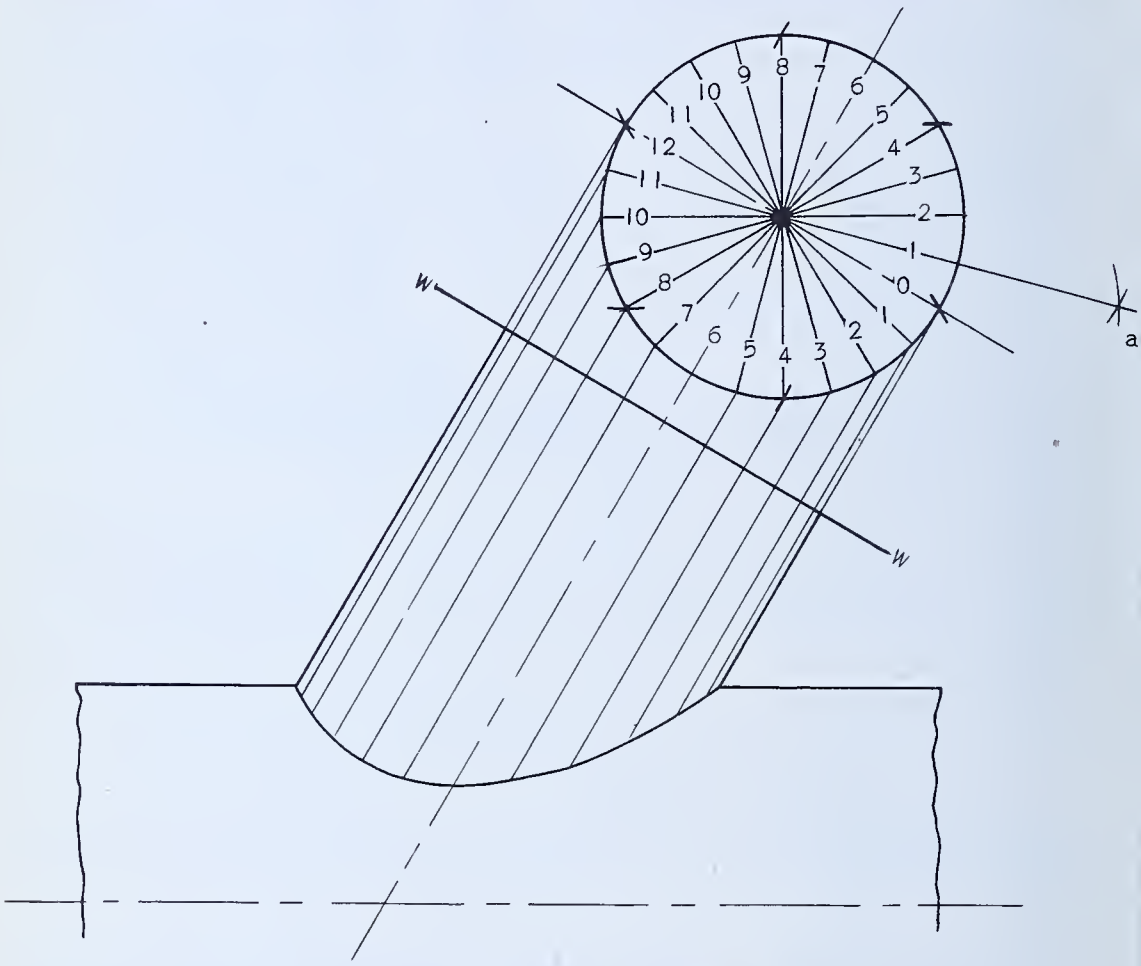


FIG. 321 — *Layout of Branch Pipe*

line 0 to the point where line 0 meets the main pipe. Mark the two 0 line distances from the base line on the template paper. See Fig. 322.

15. Reset the trammels on the distance between the working line and the point where line 1 meets the pipe and transfer this distance to the 1 lines on the template.

16. Measure along lines 2 etc. and transfer all twelve line lengths and mark from the base line all the corresponding distances on the template.

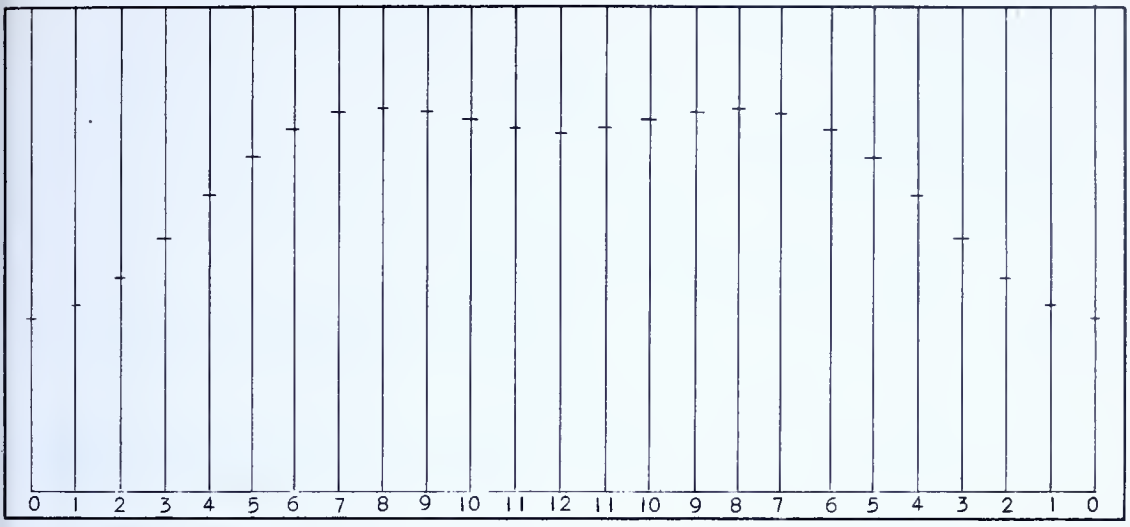


FIG. 322 — *Template Prepared for Plotting the Curve*

17. Using a pencil connect the various points, thus forming a smooth curved line. Fig. 323.

18. Cut out the template along the curved line and the base line. Trim the sides along the two 0 lines. The template is now ready for use.

19. Wrap the template around the end of the branch pipe so that the two 0 lines will come together evenly.

20. Using soapstone, trace the edge of the template on the pipe.

21. Center punch the soapstone line at 2″ intervals.

22. Have the pipe burned off on the center-punched line.

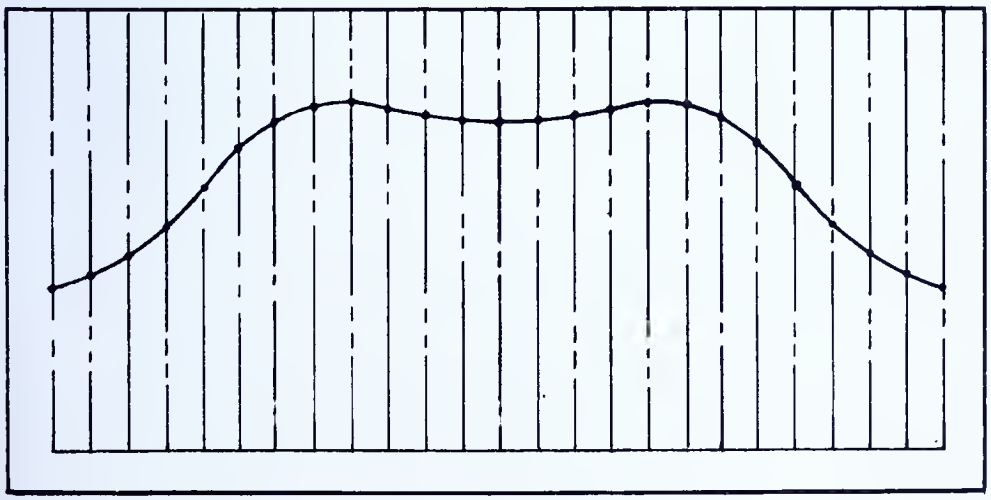


FIG. 323 — *Plotting Curve on Layout*

23. Carefully align the branch pipe at the 60° angle with the main pipe.
24. Mark with soapstone on the main line along the edge of the branch.
25. Center punch about ¼″ in from this line on the main pipe. See Fig. 318.

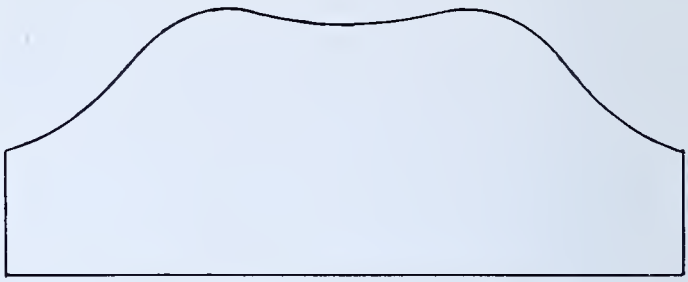


FIG. 324 — *Completed Template*

26. Have the opening burned in the main pipe.
27. The branch pipe can now be set over the opening in the main pipe and be aligned and tack welded into place. If the alignment is exact, have the job welded.

QUESTIONS

1. **What is the fundamental difference between a 90° saddle-weld joint and a 60° saddle-weld joint?**
2. **How is the opening in the main pipe marked off for cutting?**
3. **Why is the opening burned about ¼″ in from the mark on the main pipe?**
4. **Why must the lines be projected as they are in Fig. 320?**
5. **How is the curve on the template paper transferred to the pipe?**

PART VIII
BENDING PIPE WITHOUT USING TEMPLATES

JOB SHEET NO. 8
TO MAKE A 90° BEND

General Information

Pipe can be bent quickly and accurately without the use of templates. All the necessary measurements can be computed arithmetically and can then be marked on the pipe. The pipefitter bends the pipe according to the measurements marked on the pipe. In order to bend pipe by this method the pipefitter must first understand the parts and functions of a bend. The parts of a bend are the same, regardless of the angle or size of the bend. A ninety degree bend will be used to explain the fundamental parts of a bend. See Fig. 325.

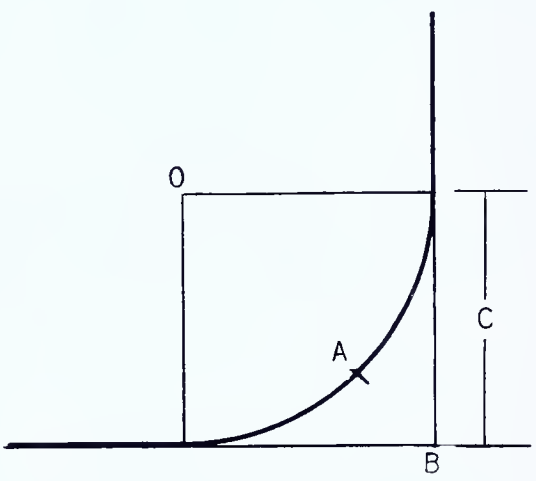


Fig. 325 — 90° *Bend*

Finding the Length of the Arc

A is the arc or bend. In order to find the length of the arc, the circumference of a circle having the same radius as the neutral axis of the bend in the pipe must be found. For example, a five-inch pipe will be bent to a 25″ radius. The circumference of a circle having a radius of 25″ is 3.1416 x 50 (π x D) or 157″. The angle of the bend determines the proportionate part of the circumference of the circle that is included in the bend. For a 90° bend the length of the bend or arc is ¼ of the circumference. For the example given above the length of the bend would be 157 ÷ 4 or 39¼″.

Following is a table showing the proportionate parts of a circle for various bend angles.

To Get the Length of the Bend:

180° = 1/2 circle — divide the circumference by 2
120° = 1/3 circle — divide the circumference by 3
90° = 1/4 circle — divide the circumference by 4
60° = 1/6 circle — divide the circumference by 6
45° = 1/8 circle — divide the circumference by 8
30° = 1/12 circle — divide the circumference by 12
22½° = 1/16 circle — divide the circumference by 16

If the bend angle is different from the ones listed above, the length of bend is obtained by multiplying the circumference of the circle by the number of degrees of the bend and then dividing the result by 360.

Example: The length of the bend made by a 15″ radius forming an 80° angle is to be found.

The circumference of 94.3″ × 80 = 7544″.

7544″ ÷ 360 = 20.9″ or approximately 21″.

The table below lists the circumference of the circles whose radii are given in the bending tables. These circumferences are used when the length of the arc is to be obtained.

10″	radius 62.8″	19½″	radius 122.5″
12″	radius 75.41″	24″	radius 150.8″
15″	radius 94.3″	25″	radius 157″
17½″	radius 109.9″	30″	radius 188.5″
18″	radius 113.1″	36″	radius 226.2″

B (Fig. 325) is the center of the bend. Care must be taken not to confuse the center of the bend with the center of the arc. The center of the arc is on the curve with center *A*, Fig. 325, while the center of the bend is outside the curve at *B*, Fig. 325.

C (Fig. 325) is the distance from the center of the bend to the start of the bend. This measurement depends upon the angle of the bend and upon the bend radius used. In a 90° bend, this distance will be the same as the radius of the bend + allowance for spring.

For angles other than ninety degrees, this measurement is found by bisecting the angle formed by the radii to the points of tangency. See Fig. 326. Then by solving for the side

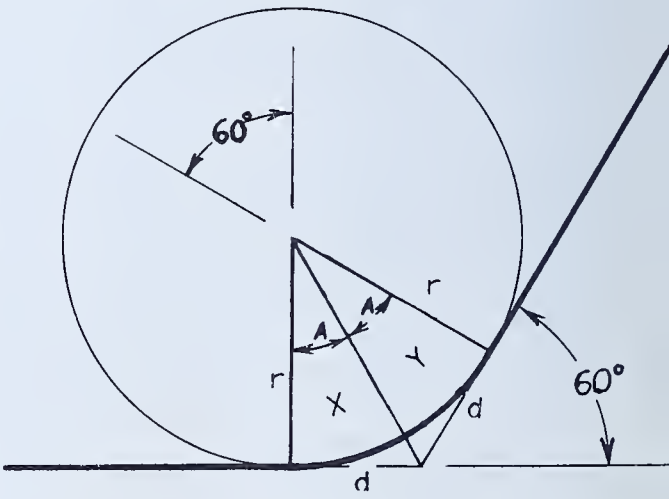


Fig. 326 — *Obtaining Center-of-Bend to Start-of-Bend Distance*

opposite the central angle, in one of the triangles thus formed, the distance from the center of the bend to the start of the bend will be found. In Fig. 326 the included angle is known to be 60°. By bisecting this angle, two equal right triangles x and y are formed. The central angles are 30° and the length of the sides opposite these angles must be found to obtain the center of the bend at starting point of bend distance. The radii forming the bases of these triangles are known since they are made to the bend radius of the particular size of pipe being used. Side d equals r times the tangent of the opposite angle or $d = 30 \times .577 = 17.31''$ or approximately 17 5/16″.

Allowance for Spring

When pipe is bent, allowance must be made for springing of the pipe. That is, if a pipe is bent to an exact angle of 90°, the pipe will spring back when it is released from the machine and the resulting angle will be less than 90°. The distance from the center to the starting point of bend will be less than the desired distance and the length of the arc will be less. With an 18″ radius at a 90° angle, the center to starting point of bend distance would have to be about one inch longer. This difference in distance is in proportion on other bends down to a 60° angle. There is very little springing in bends under a 60° angle.

In the foregoing was given an explanation of the fundamentals underlying the theory of bending pipe accurately without the use of templates. The basic principles explained above were used in the development of the tables. In order to use the tables proficiently the mechanic must understand these basic principles.

The list below gives the approximate length that must be added to get the correct 90° bend.

Using a 10″ or 12″ radius the difference will be about ½″

Using a 15″ radius the difference will be about ¾″

Using a 17″ — 18″ — 19½″ radius the difference will be about 1″.

Using a 24″ or 25″ radius the difference will be about 2″.

Using a 29″ — 30″ — 36″ radius the difference will be about 3″.

The bending machine operator must be familiar with the amount of spring that will occur in bending pipe. This spring will vary with different bending machines and will vary slightly with the type of pipe that is being bent.

JOB SHEET NO. 9
TO BEND AN OFFSET

General Information

In order to bend an offset without using a template, the angle of the bend necessary to obtain the desired center-to-center distance must be computed. If the amount of offset *A*, Fig. 327 is greater than the center-to-center distance *B*, the bend angle will be greater than 45°. If the amount of offset *A* is less than the center-to-center distance *B*, the angle of bend will be less than 45°. With distances *A* and *B* equal, the bend angle will be 45°. if the ratio of "offset to angle" is kept in mind, the mechanic can estimate the approximate degree of bend required, quickly and accurately.

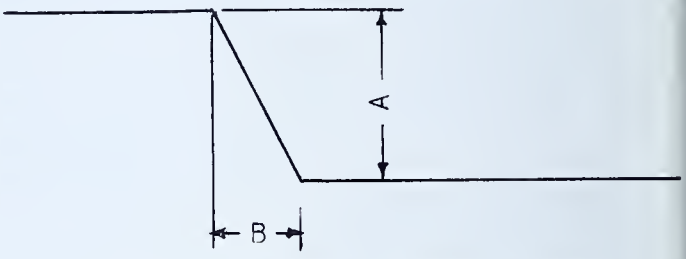


Fig. 327 — *Ratio of Offset to Angle*

Example: To bend a pipe as shown in Fig. 328.

A 4′ offset is wanted in a 3½″ pipe. Center-to-center distance, distance from end-to-center of first bend, and end-to-end distances are given. See Fig. 328.

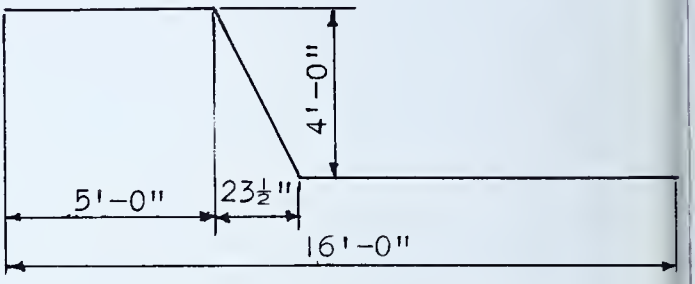


Fig. 328 — *Four-Foot Offset*

Procedure

1. In the second column of Table No. 1, Page 254, opposite 60° find the number .577.

2. Multiply the amount of offset, 48″, by .577.

   This will give 27.69 or 27 11/16″ which is very close to the desired center-to-center distance of 2′ 3½″. A 60° bend is indicated.

3. Find the distance to the starting point of the first bend.

   To find this distance, look in the table for an 18″ radius. The dimension given opposite 60° is 10½″. Subtract this amount from the end-to-center dimension of 5′ and obtain 4′ 1½″. Fig. 329.

4. Find the distance from the start of the first bend to the start of the second bend.

   (a) Multiply the amount of offset (48″) by the number opposite 60° in Table No. 1, 48″ x 1.15 = 55¼″.

   (b) Turn to the 18″ Radius Table and find the center-to-starting point of bend distance (10½″), and the length of arc (18¾″).

   (c) Double this distance (10½″) and then subtract the length of the arc from the result.
   10½″ x 2 = 21″;
   21″ − 18¾″ = 2¼″.

   (d) Subtract this 2¼″ from the distance between bends found in Step *a*. 55¼″ − 2¼″ = 53″. This will be the distance from the starting point of the first bend to the starting point of the second bend.

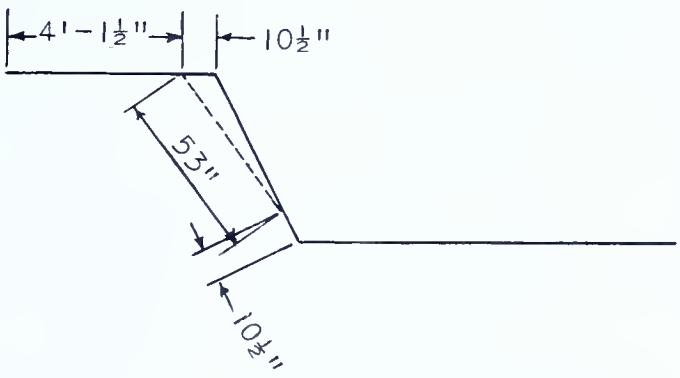


FIG. 329 — *Obtaining Measurements for Bending an Offset*

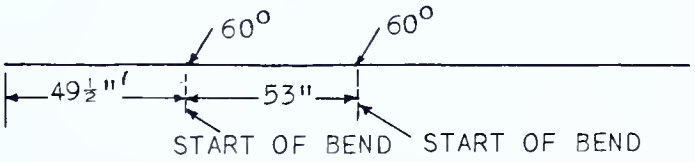


FIG. 330 — *Pipe Marked for Bending*

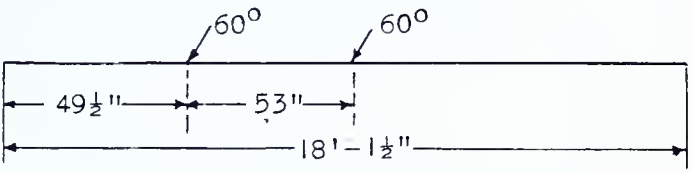


FIG. 331 — *Computed Length of Pipe*

5. Mark the pipe as shown in Fig. 330. With these dimensions on the pipe, it can be taken to the bending machine where the operator can make the required bends.

To Determine the Length of Pipe

To determine the length of pipe needed to make the desired bend, subtract the center-to-center measurement from the starting point to starting point of bend. Add this to the over-all measurement. This will give the necessary amount of pipe to make the bend according to specifications.

53 in. — 27½ in. equals 25½ in. plus 16 ft. equals 18 ft. 1½ in.

JOB SHEET NO. 10
TO BEND A "JUMP-AROUND"

General Information

Other types of bends are computed in a manner similar to the method used for computing an offset bend. A jump-around (Fig. 332) is equal to first and third bends and a central bend equal to the sum of the other two bends. This bend is computed as two offsets. Determine the start-to-start distance of the first and second bends. To this amount add the length of the arc of the first bend. This will give the distance from the starting point of the second bend to the starting point of the third bend. When all measurements have been obtained, the pipe is marked, and the bends are then made according to the markings.

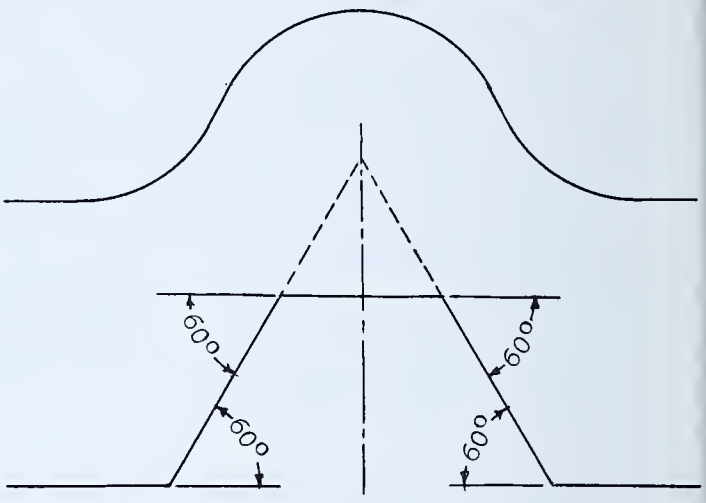


Fig. 332 — *Jump-Around and Explanatory Sketch*

Example: To bend a 10″ jump-around with a 62″ center of first bend to center of last bend distance in a 3½″ pipe (18″ radius). The distance from the end of the pipe to the center of the first bend is to be 30″.

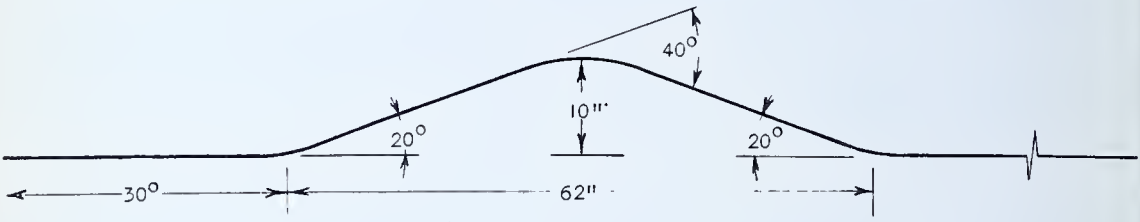


Fig. 333 — 10″ *Jump-Around*

Procedure

1. Find the distance from the center of the first bend to the center of the second bend.
   The overall center-to-center distance is 62″; one-half this distance will be the distance required or 31″.

2. Find the angle of bend for which the center-of-bend to start-of-bend distance, added to the center-of-bend to center-of-bend will most closely equal 31″.
   (a) Opposite 20° in Table I find the number 2.74.

(b) Multiply this by 10″ to get the center-to-center distance of 27½″.

(c) Opposite 20° on the 18″ radius Table find the center to start-of-bend distance 3 ⅜″.

(d) Add the two numbers obtained to get the approximate required distance of 30⅞″ which is close enough to 31″.

3. Find the start of the first bend from the end of the pipe.

The distance from the end of the pipe to the center of the first bend is 30″. The center-of-bend to start-of-bend distance 3⅜″ (taken from the 18″ radius Table) subtracted from this amount will give the distance as 26⅝″.

4. Find the distance from the start of the first bend to the start of the second bend.

(a) Multiply the amount of offset (10″) by the number (2.924) opposite 20° in Table No. 1.

10″ x 2.924 = 29¼″.

(b) Turn to the 18″ radius table and find the center-of-bend to start-of-bend distance 3⅜″ and the length of the arc (6 5/16″).

(c) Double the center-to-start distance (3⅜″) and subtract the length of arc from the result.

3⅜″ x 2″ = 6¾″; 6¾″ — 6 5/16″ = 7/16″.

(d) Subtract this amount (7/16″) from the distance between bends found in Step *a*.

29¼″ — 7/16″ = 28 13/16″. This is the distance from the start of the first bend to the start of the second bend.

5. Find the distance from the start of the second bend to the start of the third bend.

Add the length of arc (6 5/16″) to the start-to-start distance previously found 28 13/16″ + 6 5/16″ = 35⅛″. This is the distance from the start of the second bend to the start of the third bend.

6. Mark the pipe according to the measurements obtained. See Fig. 333.

Table No. 1

Degrees	To Find the Amount of Pipe Between Bends	To Find the Measurement of an Offset
5°	11.474	11.430
10°	5.758	5.671
15°	3.864	3.732
20°	2.924	2.747
25°	2.366	2.144
30°	2.000	1.732
35°	1.743	1.428
40°	1.556	1.191
45°	1.414	1.000
50°	1.305	.839
55°	1.220	.700
60°	1.155	.577
65°	1.103	.466
70°	1.064	.364
75°	1.035	.268
80°	1.015	.176
85°	1.003	.087
90°	1.000	.000

10″ RADIUS TABLE

Degrees	Distance From Center of Bend to Start of Bend	Length of Arc
5°	7/16″	7/8″
10°	7/8″	1 3/4″
15°	1 5/16″	2 5/8″
20°	1 3/4″	3 1/2″
25°	2 1/4″	4 3/8″
30°	2 11/16″	5 3/16″
35°	3 5/32″	6 1/8″
40°	3 5/8″	7″
45°	4 1/8″	7 7/8″
50°	4 11/16″	8 3/4″
55°	5 3/16″	9 5/8″
60°	5 13/16″	10 7/16″
65°	6 3/8″	11 3/8″
70°	7″	12 3/16″
75°	7 11/16″	13 1/8″
80°	8 3/8″	14″
85°	9 3/16″	14 7/8″
90°	10″	15 11/16″

12″ RADIUS TABLE

Degrees	Distance From Center of Bend to Start of Bend	Length of Arc
5°	1/2″	1 1/16″
10°	1 1/16″	2 1/16″
15°	1 9/16″	3 1/8″
20°	2 1/4″	4 3/16″
25°	2 11/16″	5 1/4″
30°	3 1/4″	6 1/4″
35°	3 3/4″	7 5/16″
40°	4 1/4″	8 3/8″
45°	4 15/16″	9 7/16″
50°	5 5/8″	10 1/2″
55°	6 1/4″	11 1/2″
60°	7″	12 9/16″
65°	7 11/16″	13 5/8″
70°	8 7/16″	14 11/16″
75°	9 3/16″	15 5/8″
80°	10″	16 3/4″
85°	11″	17 13/16″
90°	12″	18 7/8″

15″ RADIUS TABLE

Degrees	Distance From Center of Bend to Start of Bend	Length of Arc
5°	5/8″	1 5/16″
10°	1 5/16″	2 3/4″
15°	2 1/32″	3 15/16″
20°	2 3/4″	5 1/4″
25°	3 5/16″	6 1/2″
30°	4 1/16″	7 7/8″
35°	4 3/4″	9 1/8″
40°	5 7/16″	10 1/2″
45°	6 1/4″	11 3/4″
50°	7″	13 1/8″
55°	7 13/16″	14 3/8″
60°	8 3/4″	15 3/4″
65°	9 9/16″	17″
70°	10 1/2″	18 3/8″
75°	11 1/2″	19 5/8″
80°	12 5/8″	21″
85°	13 3/4″	22 1/4″
90°	15″	23 9/16″

17½" RADIUS TABLE

Degrees	Distance From Center of Bend to Start of Bend	Length of Arc
5°	¾"	1 ½"
10°	1 ½"	3 1/16"
15°	2 5/16"	4 9/16"
20°	3 ¼"	6 ⅛"
25°	3 ⅞"	7 ⅝"
30°	4 11/16"	9 ⅛"
35°	5 ½"	10 11/16"
40°	6 ⅜"	12 3/16"
45°	7 ¼"	13 ¾"
50°	8 ⅛"	15 ¼"
55°	9 ⅛"	16 13/16"
60°	10 1/16"	18 ⅜"
65°	11 ⅛"	19 ⅞"
70°	12 ¼"	21 ⅜"
75°	13 7/16"	23"
80°	14 11/16"	24 ⅜"
85°	16"	26"
90°	17 ½"	27 ½"

18" RADIUS TABLE

Degrees	Distance From Center of Bend to Start of Bend	Length of Arc
5°	¾"	1 9/16"
10°	1 9/16"	3 ⅛"
15°	2 ⅜"	4 ¾"
20°	3 ⅜"	6 5/16"
25°	4"	7 ¾"
30°	4 13/16"	9 7/16"
35°	5 11/16"	11"
40°	6 9/16"	12 9/16"
45°	7 7/16"	14 ⅛"
50°	8 ⅜"	15 11/16"
55°	9 ⅜"	17 5/16"
60°	10 ⅜"	18 ⅞"
65°	11 ⅜"	20 3/16"
70°	12 ⅝"	22"
75°	13 13/16"	23 ⅝"
80°	15 ⅛"	25 1/16"
85°	16 ½"	26 11/16"
90°	18"	28 5/16"

19½" RADIUS TABLE

Degrees	Distance From Center of Bend to Start of Bend	Length of Arc
5°	7/8"	1 11/16"
10°	1 11/16"	3 3/8"
15°	2 9/16"	5 1/8"
20°	3 5/8"	6 13/16"
25°	4 3/8"	8 1/2"
30°	5 1/4"	10 3/16"
35°	6 3/16"	12"
40°	7 3/16"	13 5/8"
45°	8 1/16"	15 5/16"
50°	9 1/8"	17"
55°	10 1/8"	18 3/4"
60°	11 1/4"	20 7/16"
65°	12"	22 1/16"
70°	13 1/2"	23 13/16"
75°	15"	25 1/2"
80°	16 3/8"	27 1/4"
85°	18"	29"
90°	19 1/2"	30 5/8"

24" RADIUS TABLE

Degrees	Distance From Center of Bend to Start of Bend	Length of Arc
5°	1 1/16"	2 1/16"
10°	2 1/8"	4 1/8"
15°	3 3/16"	6 1/4"
20°	4 7/16"	8 3/8"
25°	5 5/16"	10 7/16"
30°	6 3/8"	12 9/16"
35°	7"	14 5/8"
40°	8 3/4"	16 7/8"
45°	10"	18 7/8"
50°	11 3/16"	20 15/16"
55°	12 1/2"	23"
60°	13 15/16"	25 1/8"
65°	15 5/16"	27 3/16"
70°	16 13/16"	29 5/16"
75°	18 7/16"	31 7/16"
80°	20 1/16"	33 1/2"
85°	22"	35 5/8"
90°	24"	37 3/4"

25″ RADIUS TABLE

Degrees	Distance From Center of Bend to Start of Bend	Length of Arc
5°	1 1/16″	2 3/16″
10°	2 3/16″	4 3/8″
15°	3 5/16″	6 9/16″
20°	4 5/8″	8 3/4″
25°	5 9/16″	10 15/16″
30°	6 3/4″	13 1/16″
35°	7 7/8″	15 5/8″
40°	9 1/8″	17 1/2″
45°	10 3/8″	19 11/16″
50°	11 11/16″	21 13/16″
55°	13″	24″
60°	14 1/2″	26 3/16″
65°	16″	28 7/16″
70°	17 1/2″	30 5/8″
75°	19 3/16″	32 13/16″
80°	21″	35″
85°	22 15/16″	37 3/16″
90°	25″	39 1/4″

30″ RADIUS TABLE

Degrees	Distance From Center of Bend to Start of Bend	Length of Arc
5°	1 5/16″	2 5/8″
10°	2 5/8″	5 1/4″
15°	3 15/16″	7 7/8″
20°	5 9/16″	10 1/2″
25°	6 5/8″	13″
30°	8″	15 11/16″
35°	9 7/16″	18 5/16″
40°	10 15/16″	20 15/16″
45°	12 7/16″	23 1/2″
50°	14″	26 3/16″
55°	15 5/8″	28 3/4″
60°	17 5/16″	31 5/16″
65°	19 1/8″	34″
70°	21″	36 5/8″
75°	23″	38 3/16″
80°	25 3/16″	41 3/4″
85°	27 1/2″	44 7/16″
90°	30″	47″

36" RADIUS TABLE

Degrees	Distance From Center of Bend to Start of Bend	Length of Arc
5°	1 9/16"	3 1/8"
10°	3 3/16"	6 1/4"
15°	4 3/4"	9 7/16"
20°	6 11/16"	12 5/8"
25°	8"	15 11/16"
30°	9 11/16"	18 15/16"
35°	11 3/8"	22"
40°	12 3/4"	25 3/16"
45°	14 15/16"	28 5/16"
50°	16 3/4"	31 7/16"
55°	18 3/4"	34 5/8"
60°	20 13/16"	37 11/16"
65°	23"	40 13/16"
70°	25 1/4"	44"
75°	27 5/8"	47 1/8"
80°	30 3/16"	50 1/4"
85°	33"	53 1/2"
90°	36"	56 1/2"

PART IX
LEADWORKING
General Description and Uses of Leadworking Tools and Materials

Tools and Materials Furnished by the Shipyard

GASOLINE BLOWTORCH

A one-pint capacity blowtorch is most commonly used by the lead worker. This torch is small and light enough to use on board ship where there may be a minimum of working space. The torch is used to heat soldering irons, to heat lead pipe for bending, and for heating pipe in preparation for wiping a joint. To light the torch, follow the procedure given below.

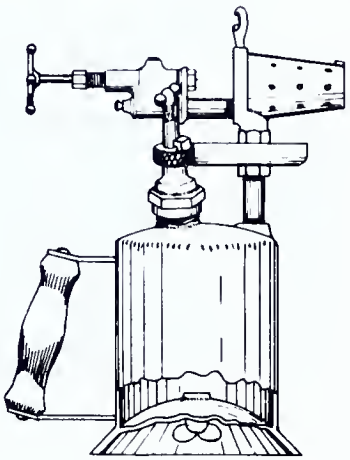


FIG. 334.—*Gasoline Blowtorch*

PROCEDURE

1. Fill the tank with gasoline.
   This is accomplished by unscrewing the filler plug in the bottom of the torch and pouring in gasoline until the level of gasoline is an inch or two below the opening. Screw the plug in tightly.
2. Pump air pressure into the torch by operating the small pump plunger four or five times.
3. Open the valve until about a tablespoonful of gasoline is in the preheater cup. Close the valve.
4. Light the gasoline in the cup and let burn until almost dry.
5. Slowly open the valve.
   A rushing sound should be heard and a light blue flame should emit from the nozzle. Sometimes the jet becomes clogged with carbon and the torch will not operate properly. This condition may be remedied by opening the valve and inserting a very thin wire through the orifice to remove the carbon.

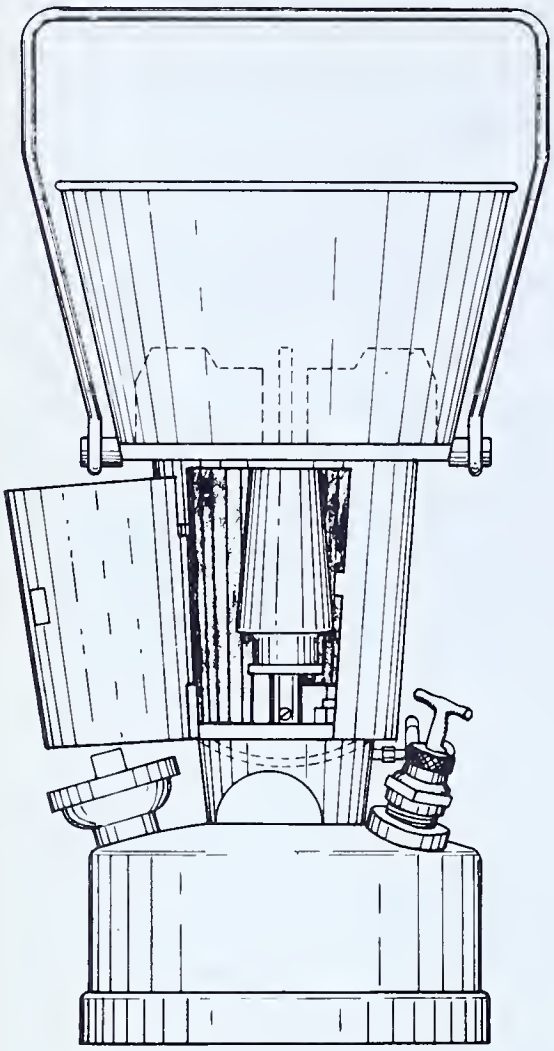


FIG. 335 — *Gasoline Furnace*

GASOLINE FURNACE

The operation of the furnace is similar to that of the blowtorch.

The furnace rests upright on the ground and emits considerably more heat than the torch. A coil on the furnace is exposed to heat and vaporizes the gasoline before it enters the burning chamber. The furnace is constructed to hold either soldering irons or a melting pot. A shield surrounding the flame throws the heat around the pot and also prevents the wind from blowing out the flame.

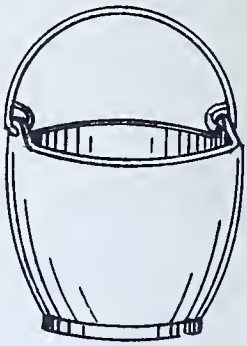


FIG. 336 — *Melting Pot*

MELTING POT

This pot, made of cast iron, is used to melt solder for wiping joints. It is shaped to fit on the gasoline furnace. The bottom is flat so that it may be carried to a job and set down without danger of upsetting. The pot holds about one quart of molten metal.

LADLE

A ladle is used to dip molten solder from the melting pot. The cup and handle are made from iron or steel. The cup should have three pouring lips such as the one shown in Fig. 337. This makes possible the pouring of solder in three directions. This is a very important feature in making wiping joints. The ladle should always be heated before it is inserted into molten lead. A wet or cold ladle will cause an explosion if dipped into hot solder. The ladle should always be kept out of the pot when it is not being used since the handle will become too hot to hold.

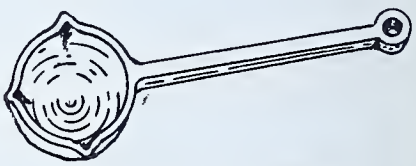


FIG. 337 — *Ladle*

TALLOW

This is cold, hard animal fat. It is usually provided melted down in barrels. The heavy grease acts as a flux when wiping joints. It coats the hot lead pipe or solder

and protects it from oxidizing. This permits the solder to stick fast and form a strong joint. It is spread on wiping cloths from time to time to prevent particles of lead from adhering to the cloth.

Soldering Paste

This is a prepared flux for use in soldering work of all kinds. It contains a heavy mineral oil and rosin. It is more effective than tallow and is used mostly in connection with the soldering iron. It prevents oxide from forming on the surface of heated lead while it is being soldered. Solder will not join with an oxidized surface.

Plumbers Soil

This is a paste made from lampblack mixed with glue and water. It acts in the same way as an oxidized surface in regard to the sticking of solder. The preparation is painted on lead pipe or sheet to which solder is not supposed to adhere. When a joint is to be wiped, the surface must first be cleaned. To prevent the solder from spreading all over the pipe, the pipe is painted with plumbers soil around the limits of the joint. This will confine the solder to the joint.

Paint Brush

The paint brush is used to spread plumbers soil over the parts that are not supposed to receive solder. The use of a paint brush to spread the soil will insure a neat appearing joint. To brush soil on a pipe, the brush is first moistened with water and then rubbed on the soil until the brush contains a sufficient amount.

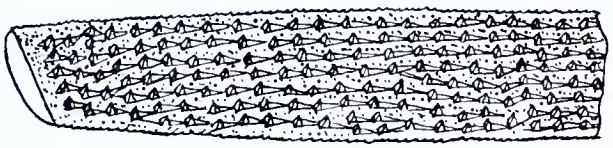


Fig. 338 — *Wood Rasp*

Wood Rasp

The wood rasp is in reality a file containing large triangular teeth. Metal may be removed rapidly with the rasp. It is used to square or bevel ends of pipe. The surfaces prepared with the rasp are ragged and have to be dressed down with a file.

Half-Round File

Fig. 339 — *Half-Round File*

The file is used for dressing down edges of sheet or pipe. A coarse-toothed file should be used, since a fine one will clog up quickly when dressing lead. The teeth of a file are much finer than those of a rasp and so the file is used for smoothing operations. If the teeth of a file become clogged with metal, the file may be cleaned by brushing with a file card or a wire-bristled brush.

Drift Plugs

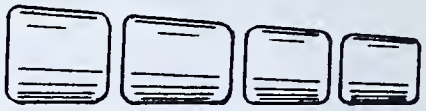


Fig. 340 — *Drift Plugs*

These plugs are made of hardwood turned to the same size as the inside diameters of the various pipes. If a large kink is found in a pipe, a small plug may be pushed through the pipe followed by larger plugs until the correct sized plug is pushed through. Before the plugs are driven through, the pipe may be carefully heated to make the lead more pliable. The number of plugs needed will depend on how badly the pipe is kinked.

Bending Iron

The bending iron or pin is made from cold rolled steel tapered down on the end to about ¼". One end of the bending iron or both ends may be bent to any desired angle. The end is inserted through a small hole in the pipe; then the edge of the hole is flared out by hammering on the bending iron until the proper flare is obtained.

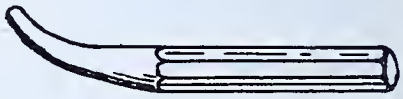


Fig. 341 — *Bending Iron*

Tools Made in the Yard by the Leadworker

Lead Dresser

The lead dresser is a wooden tool used to beat rough spots or kinks out of sheet lead or lead pipe. It is made from a hard wood such as maple, dogwood or ash. The handle is raised from the working surface of the tool so that the hand will not be hurt while beating out lead. A wooden dresser is used so that the surface of the work will not be marred. A hammer would cause deep scars on the lead.

Fig. 342 — *Lead Dresser*

Lead Paddle

The paddle is made from thin board by the leadworker. The leadworker may whittle the paddle into any shape and size he desires. For some jobs, pouring solder from the ladle is impossible because of limited space. The paddle must be used to splash solder on the joint.

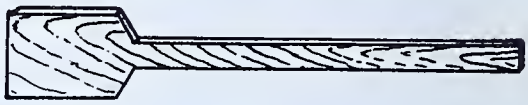


Fig. 343 — *Lead Paddle*

Mallet

The mallet is used for a similar purpose to that of the dresser. It is also used for turning lead pipe over flanges. The mallet

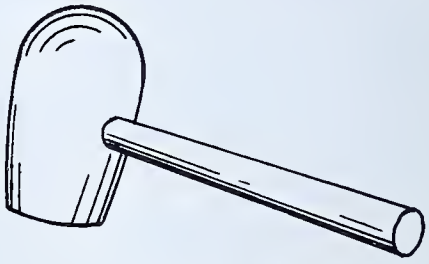


Fig. 344 — *Mallet*

is usually made of hardwood but rawhide mallets that are superior in lasting quality can be purchased. The handle of the mallet is about 12″ long. The head should be rounded on top and flat on the bottom.

Wiping Cloth

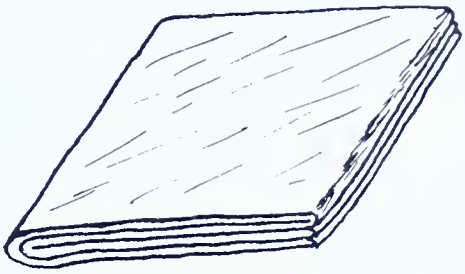


Fig. 345 — *Wiping Cloth*

Wiping cloths are used to spread and shape the solder on wiping joints. They are made from material such as moleskin, felt, or ticking. A joint wiped with moleskin will be smoother than one wiped with ticking. They are made in varying sizes to suit the size of joint. They may be 2″ x 3″, 3″ x 3″, 3″ x 4″, or 4″ x 4″ or any other handy size. They are made up of several layers of cloth. They must be thick enough so that the fingers will not be burned when a joint is wiped. In order to make a smooth joint, a new cloth should be soaked with tallow or oil. Particles of solder will stick to a dry cloth.

Scriber

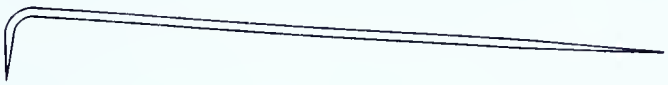


Fig. 346 — *Scriber*

The scriber is a tool with a sharpened point used to mark lines on lead. The scriber is used on lead in the same manner that a pencil is used on wood. A scriber can be made from a piece of drill rod or hard welding rod by grinding down the ends to a sharp point. Marks on lead made with a scriber show up as bright scratches.

Lead Bob

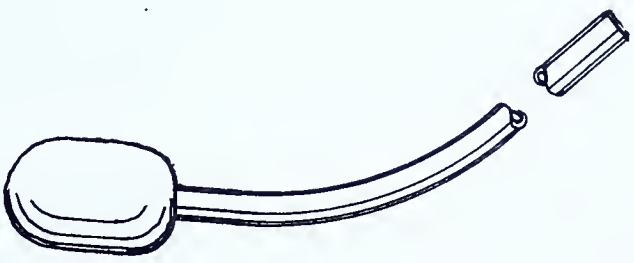


Fig. 347 — *Lead Bob*

The lead bob is used to straighten out kinks in elbows or bends where the bend is such that the kinks can be reached with the bob. This tool is also used to drive drift plugs through a short length of pipe. The lead bob is made by repeatedly dipping the end of a ⅜″ brass pipe into molten solder until a ball about 3″ long is formed on the end. The brass pipe can then be bent to any shape desired.

Lead Knife

A lead knife is used to cut sheet lead or to trim lead pipe. The leadworker usually makes his own lead knife by grinding down an old power-hacksaw blade to the required shape. Fiber or wooden handles can be riveted to the blade as a matter of safety.

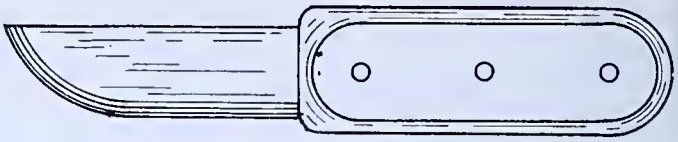


Fig. 348 — *Lead Knife*

Tools Furnished by the Leadworker

Crosscut Saw

This is a regular woodsaw such as the one carpenters use. It is used, rather than a metal hacksaw, for cutting off lead pipe. A hacksaw, because of its fine teeth, will clog up after a few strokes. The wood saw has larger teeth (8 or 10 per inch) and consequently will not clog if properly used. The saw should be greased with tallow or oil to keep it from sticking to the lead.

Fig. 349 — *Crosscut Saw*

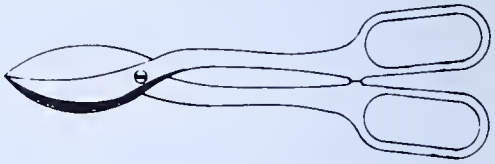


Fig. 350 — *Tin Shears*

Tin Shears

This tool is commonly used by sheet metal workers but it is also a very valuable tool to the leadworker. He uses the shears to cut and trim lead. Curves are cut more easily with shears than with a knife. Of the many types of tin shears available, the one used by the leadworker is the straight 14″ shears.

Dividers

The type used most often by the leadworker is the common Yankee-type spring dividers. The dividers are used on sheet lead in the same manner as a compass is used on paper. They are valuable in scribing arcs and circles. The sharp points leave bright scratches marking the curves. The points are often used as a substitute for a scriber.

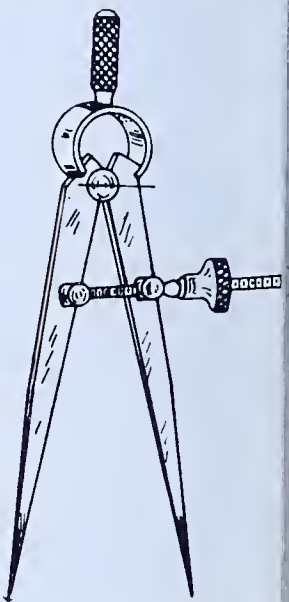


Fig. 351 — *Dividers*

Soldering Iron

The most common type of soldering iron used by the leadworker is a fairly heavy one (10 oz. or 12 oz.). The name soldering iron is misleading because the head or the part actually used to solder is made from a solid piece of copper. This point is fastened onto an iron or steel handle about 12″ long. The end of the

Fig. 352 — *Soldering Iron*

iron handle is covered with a wooden grip to protect the hands from the heat. The soldering iron is heated in a furnace or a torch until hot enough to melt solder. Before it is used the point should be cleaned by filing. After the point is clean, soldering paste should be applied and the point should be tinned or coated by being rubbed on solder. The soldering iron will now hold several drops of solder. The copper points are usually forged down to a square point but some mechanics prefer to forge their coppers to a wedge-shaped point.

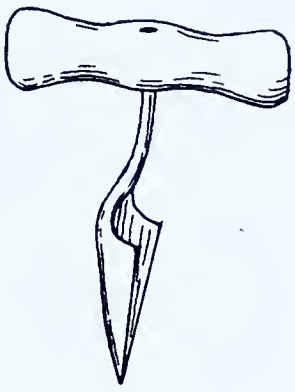


FIG. 353 — *Tap Borer*

TAP BORER

The tap borer is a special tool used to bore holes in pipe for making branch joints on cleanouts. The borer is cone shaped with a sharp cutting edge extending up one side of the cone. The tool is used to bore any size of hole needed. The tee handle is twisted (while a little pressure is applied) to cut holes.

SHAVE HOOK

This tool is used as a scraper to clean lead surfaces prior to soldering. Many shapes and sizes are available but the use of all of them is identical. The cutter is made from hard steel sharpened to a beveled edge. Very little pressure is needed to brighten lead with the shave hook, if the blade is kept sharp.

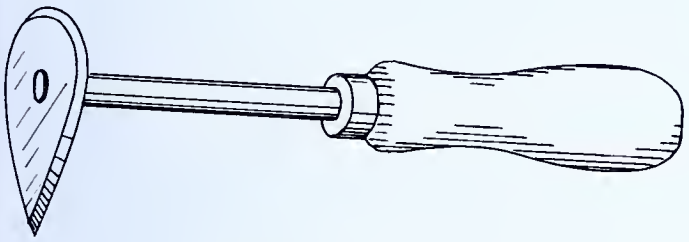


FIG. 354 — *Shave Hook*

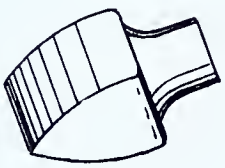


FIG. 355 — *Edging Tool*

EDGING TOOL

An edging tool, sometimes called a corner tool, is used to tap lead into sharp corners or bends. This tool is also used to mark lead for bends. It is made from a hard wood and can be tapped with a mallet. The head is about 4″ wide and 1½″ thick and it is tapered into a wedge shape. The point of the wedge is slightly rounded so that the lead will not be cut.

FIG. 356 — *Turn Pin*

TURN PIN

The turn pin is a cone shaped tool made from hardwood, polished

down to a smooth surface. It is placed in the end of a piece of pipe and struck with a mallet to produce a flare. It may also be used to smooth out a flare made by a bending iron.

Pliers

Of all the different types of pliers available the most suitable for leadworking are the pipe or gas pliers of the kind found in the toolkit of all new automobiles. The jaws are serrated or grooved to prevent slipping. Pliers are used to tear lead sheet after it is marked with a knife, for pulling tacks, for picking up hot objects, and for a variety of other uses.

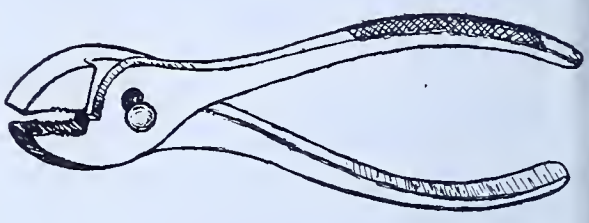


Fig. 357 — *Pliers*

PART X
LEADWORKING OPERATIONS

OPERATION NO. 1
TO PREPARE AND CARE FOR WIPING-SOLDER

Solder Mixture

In order to make a neat, strong wiping joint, one of the first things to consider is the solder that is to be used. Skill alone in wiping a joint will not insure a good job. Wiping-solder is softer and more pliable than ordinary solder. If it does not contain the proper mixture it will be too fine or too coarse to wipe properly.

The common mixture for a pot of wiping-solder is about 8 lbs. of block tin and 12 lbs. of pig lead. If a new mixture is to be mixed, a small piece of rosin should be placed in the pot while the lead and tin are melting. The rosin serves as a flux and brings to the surface all the scum and dirt that may be in the blocks. This dirt may be removed by skimming it off with a ladle. Wiping-solder also comes prepared in 2½ lb. and 5 lb. blocks. If these blocks are used, the solder must be cleaned in the same manner.

Judging Correct Temperature and Mixture

After the solder is melted it should be stirred thoroughly. A simple test for judging the correct temperature is made by dipping a piece of white paper into the metal. If the paper will char without bursting into flames the solder is at the correct temperature for wiping. To test for the correct mixture of tin and lead, a small amount (about a teaspoonful) of the molten material should be poured on a cold level surface such as a clean section of concrete floor or a steel plate. After the metal has cooled on the plate, there should be about four bright spots visible on the surface. The appearance of fewer spots indicates that the mixture does not contain a sufficient amount of tin. If more than four spots appear, shortage of lead is indicated.

Pure lead will melt at about 620° F. and pure tin will melt at about 450° F. A mixture of the two, however, will melt at 446° F, which is a lower temperature than either of the pure metals. It can be readily seen that the temperature of the mixture, if not overheated, will not melt the lead pipe during the wiping operation.

Cleaning the Molten Solder

The unused solder in the melting pot will become dirty and contaminated after a time. Foreign matter can be brought to the surface by adding a small piece of rosin or tallow to the molten metal. It may then be removed with the ladle. If the mixture is allowed to become too hot, the tin will burn out and will have to be replaced to keep the proper mixture. For this reason the mixture should be tested by the spot method from time to time.

Removing Foreign Matter

If galvanized material is soldered, or droppings on the floor are put back into the pot, the mixture may gradually take on zinc. This makes the mixture sluggish and brittle. The zinc may be removed by heating to a temperature of 775° F. (This temperature may be checked by dipping a piece of paper into the metal and quickly removing it. If the paper bursts into flame the proper temperature has been reached.) The zinc will melt at this temperature and because it is lighter than the other metals it may be skimmed off the top. Sulphur or rosin dropped into the pot will aid in collecting the foreign matter.

Safety

Several matters of safety must be observed when working with solder. Whenever solder is heated to any great extent, poisonous fumes are given off. The worker should not work around the lead pot more than is absolutely necessary. The fingers should never be allowed to touch the mouth or to touch food being eaten after working with lead. Lead poisoning is the painful and serious result of getting lead into the human body. Cold or wet ladles or solder blocks should never be dropped into melted solder as an explosion causing serious burns can result. When repairing waste systems, disinfectant should be used liberally in the line, and after the job is completed, a disinfectant soap should be used to wash the hands thoroughly.

Tools and Equipment	Materials
1. Plumbers furnace	Blocks of wiping-solder
2. Melting pot	Rosin
3. Ladle	Sheet of white paper

Procedure

1. Light the furnace.
2. Place the melting pot on the furnace.
3. Drop four 5 lb. blocks of wiping-solder into the melting pot.
4. Drop several small pieces of rosin into the pot.
5. Skim off the floating slag after the solder has melted.

6. Dip a piece of white paper into the solder.

   If the paper turns brown, the solder is at the proper temperature for wiping.

7. Scoop solder into the ladle and pour about a teaspoonful of solder upon a clean level surface.

   Check for proper mixture by observing the bright spots that appear on the surface of the cooled solder. Four spots appear on the surface if the solder contains the correct mixture.

QUESTIONS

1. **What is the most important property of wiping-solder?**
2. **Why is it important to have the solder at the correct temperature?**
3. **How is the temperature of molten solder estimated?**
4. **Explain the method of cleaning solder.**
5. **To what dangers are leadworkers exposed?**

OPERATION NO. 2
TO BEND A 2″ LEAD PIPE

General Information

In bending lead pipe, just as in bending iron or steel pipe, a knowledge of the action occurring in a pipe when bending it will aid the mechanic in doing his job correctly. A deck of cards will serve to illustrate the action of pipe being bent. If a deck of cards is stacked neatly in a pile and is then picked up and bent between the thumb and fingers it is seen that the cards on the outside of the bend appear shorter than the ones on the inside of the bend. The ones on the inside extend outward on either side. In other words the distance around the outside of the curve is greater than that around the inside. With the deck of cards, the individual layers could slide on each other, and no strains would be set up either on the inside or outside of the bend. In the case of the pipe there can be no sliding, and consequently something else must happen to permit the bend. If thin evenly spaced rings were painted around the pipe before it was bent, it would be seen after the bend had been made that the rings on the outside of the bend are farther apart than on the straight pipe; that the rings along the center line are the same distance apart; and that the rings along the inside of the curve are closer together. See Fig. 358. The pipe wall therefore, must have stretched along the outside of the bend and must have been compressed or squeezed together along the inside of the bend.

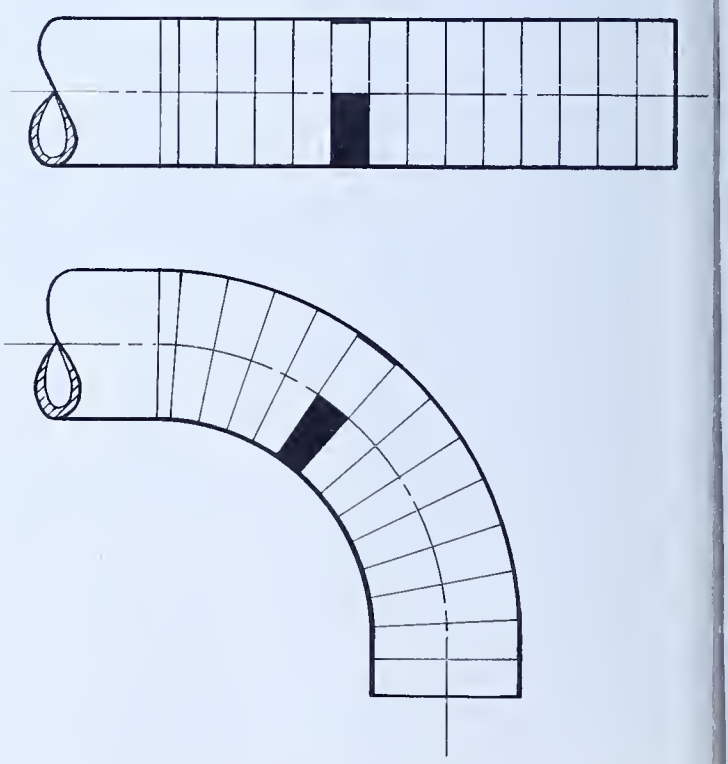


Fig. 358 — *Detail Showing the Effects of Bending*

This compressing and stretching occurs under ideal conditions. If no thought is given to bending stresses, the pipe could be bent and the walls, rather than stretch and compress in the proper places, would buckle or flatten at the bend. To prevent this, the following procedure is observed in bending lead pipe:

Tools and Equipment	Materials
1. Hammer	Lead pipe
2. Lead dresser	½ doz. 6d nails
3. Mallet	2 wooden plugs
4. Template	Dry sand
5 Air bending machine	

Procedure

1. Examine the pipe for kinks. If there are any, they should be straightened out before the pipe is bent.
2. Plug one end of the pipe with a wooden plug and nail the plug in place with three nails. See Fig. 359.

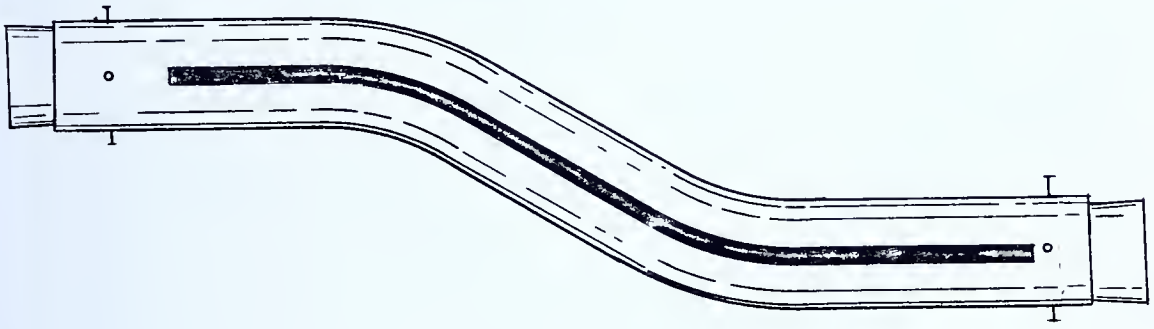


Fig. 359 — *Pipe Bent to Conform with a Template*

3. Fill the pipe with dry, cool sand.

   Tap the pipe with the lead dresser (while it is being filled) to pack the sand tightly. Care should be taken not to dent the pipe.
4. When the sand ceases to settle, drive a plug in the open end of the pipe and nail it in place.
5. Bend a template to the radius of the form to be used and to the desired bend.
6. Place the pipe on the air-bending machine and locate the center of the bend with the center of the radius form.
7. Turn on the air and start bending the pipe.

   The template should be placed over the pipe while this is being done.
8. Allow the pipe to be bent at a slightly greater angle than that of the template.

   After the pipe is removed it should be bent back to conform to the template. This removes the tendency of the pipe to "spring back".
9. Remove the plugs and empty the pipe of sand.
10. Cut the pipe to the proper size, allowing one inch on each end for the joint or flange.

QUESTIONS

1. What happens to the walls of a pipe when it is bent?
2. How is flattening prevented when a pipe is bent?
3. Explain what is meant by "spring" in a pipe.
4. Why should dry sand be used to pack a pipe?

OPERATION NO. 3
TO TAKE A DENT OUT OF A BEND

General Information

If a 90° bend is kinked, the kinks may be straightened out with the lead bob or dummy. All 90° bends are made with cleanouts located on the lower side of the bend. The kinks are heated with a torch while the bob is inserted through the cleanout hole and used to beat out the kinks. Care must be taken in heating the pipe. If the pipe is overheated the lead will melt and collapse, thus ruining the entire section of pipe. After the kink is taken out, the pipe can be shaped up with the dresser.

If the pipe contains a long curve without a cleanout, bobbins will have to be used to straighten out any kinks that may be present. Fig. 360. Bobbins are balls or plugs made from hardwood (usually 3 or 4 needed) ranging in size up to the inside diameter of the pipe that is to be straightened. The smallest bobbin is pushed through first, followed by the next largest, and so on until the bobbin fitting the inside of the pipe is pushed through. The bobbins are pushed through the bend with the lead bob. Heating the kinks will make the job easier.

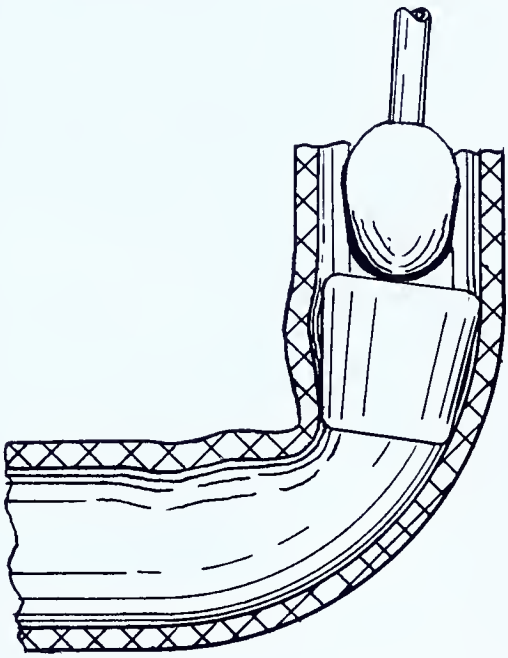


Fig. 360 — *Removing a Kink*

Tools and Equipment

1. Lead bob
2. Bobbins
3. Lead dresser
4. Blow torch

Materials

1 dented lead elbow

Procedure

1. Heat the elbow with the blowtorch.
2. Insert the smallest bobbin and push it through the elbow with the dummy rod.
3. Push a larger bobbin through the elbow.
4. Smooth out any bulges with the lead dresser.
5. Reheat the elbow and push the third plug through.

6. Push the bobbin, the same size as the inside diameter of the pipe, through the pipe.
7. Smooth out the elbow with the lead dresser.

QUESTIONS

1. **How are dents removed from a pipe if the dummy rod cannot be used?**
2. **Why should dents be heated before they are removed?**
3. **How are bobbins made?**
4. **What material might be used to permit the bobbins to be pushed through the pipe more easily?**

OPERATION NO. 4
TO PREPARE AND WIPE A STRAIGHT JOINT

General Information

Wiping lead joints is one of the most frequent and difficult jobs experienced by the leadworker. The first consideration in making a wiping joint is the solder itself, the second is the preparation of the pipe for the joint, and the third is the actual wiping process which requires a high degree of skill. A poorly constructed joint may leak or break under service, or it may obstruct the flow through the pipe. To prevent abrupt edges that may collect material and block the flow, the male portion should always be pointed in the same direction as the flow.

Tools and Equipment

1. Rasp
2. Shave hook
3. Turn pin
4. Hammer
5. Rule
6. Paint brush
7. String
8. Lead pipe
9. Vee blocks
10. Blowtorch
11. Gasoline furnace
12. Soldering iron
13. Wiping cloth
14. Melting pot
15. Ladle

Materials

Solder
Tallow
Plumbers soil

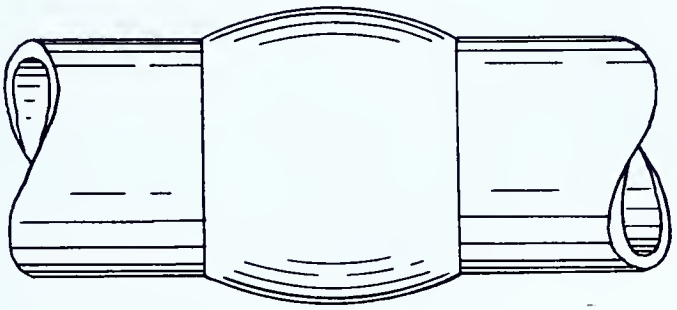


Fig. 361 — *Wiped Joint*

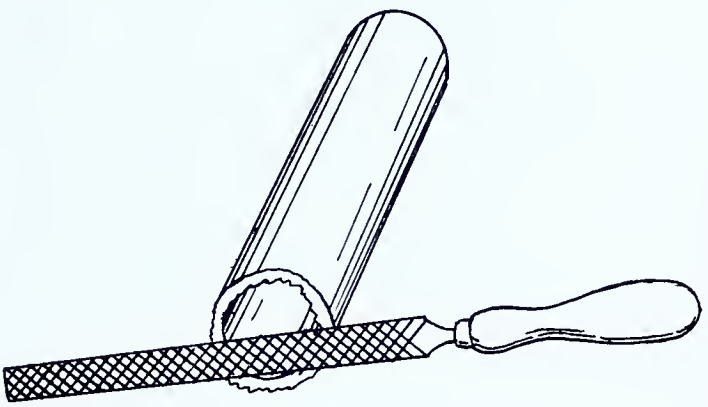


Fig. 362 — *Squaring Pipe End*

Procedure

1. Rasp the ends of the two pieces of pipe until they are square with the bore. Fig. 362.
2. Use the shave hook to clean out the burr from the squared ends of the pipes. Fig. 363.

3. Drive the turn pin into the squared end of one of the pipes.

   This will flare out the end and form the female part of the joint. Fig. 364.

4. Clean out the inside of the female end with the shave-hook and apply tallow.

5. Taper the male end of pipe with a rasp so that it will fit into the female part.

   This taper should be more gradual than that in the female part. This allows space for the solder to "sweat" into the joint, thus making the joint stronger.

6. Roughen the ends of the pipe with sand paper or emery cloth so that soil will stick to the pipe.

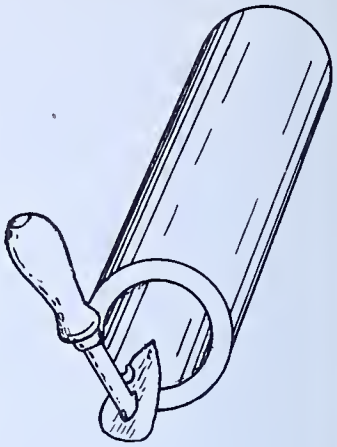


FIG. 363 — *Removing the Burr*

7. Mark the pipes about four inches in from the ends.

8. Paint these ends with plumbers soil.

9. 2″ from the ends, coil a piece of string around the pipe and pull tight.

   This will mark a smooth ring around the pipe.

10. Using the shave hook brighten the pipe from this ring in to the end of the pipes.

11. Rub tallow on the brightened surface to prevent oxidation.

    This brightened space will gather solder and the soil will limit the size of the joint.

12. Line up the pipes in the vee blocks or secure on bench so that there is sufficient space for wiping and insert the male end into the female end. Fig. 365.

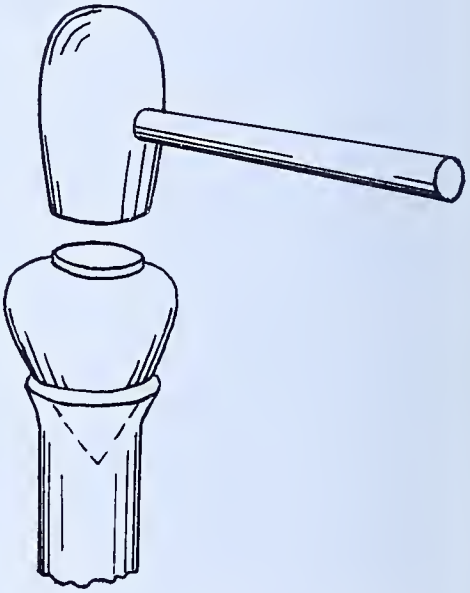


FIG. 364 — *Flaring a Pipe End*

13. Tack the two pieces together with a soldering iron. Use 50/50 solder for the tack.

14. Place a sheet of paper under the joint to catch any lead that may drop down.

15. Heat the lead to the proper temperature and test for the correct mixture.

16. Preheat the joint with the blowtorch.

17. Dip out a ladle-full of solder and pour over the joint.

    The wiping cloth should be held under the joint while the metal is poured on it. The ladle should be moved back and forth so that the solder will be evenly dis-

tributed. As solder falls into the cloth, press against the pipe to start forming the joint. The cloth must be moved constantly while the solder is poured.

18. When the solder becomes mushy and pliable, stop pouring.

19. Hold the wiping cloth in one hand so that the first three fingers form an arch.

Pressure is applied to the first and third fingers while the second finger is relaxed. Fig. 366.

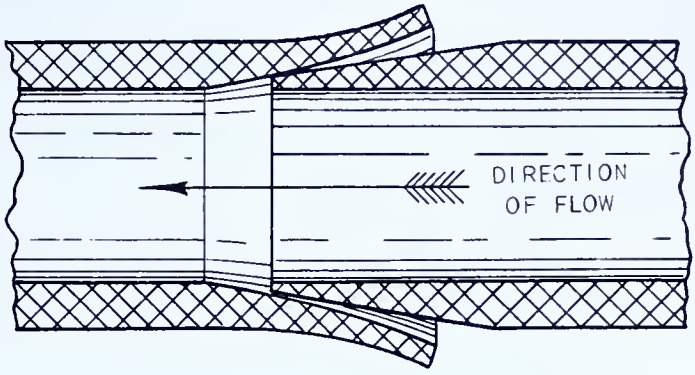


FIG. 365 — *Joint Ready for Wiping*

20. Wipe up from the bottom forming a smooth even bead, first on one side and then on the other.

It will be necessary to heat the solder while it is being wiped to keep the solder pliable. The solder must be heated carefully. If too much heat is applied it will run to the bottom of the joint.

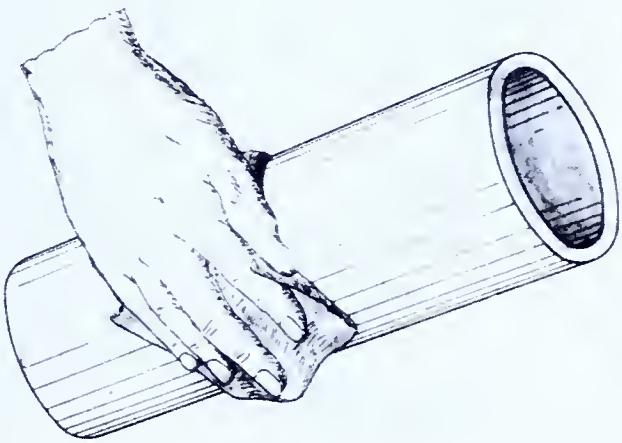


FIG. 366 — *Wiping a Joint*

21. Continue wiping toward the top until a smooth even bead is made.

QUESTIONS

1. **How are lead pipe sections usually joined together?**
2. **What precaution must be observed when making a joint in lead pipe?**
3. **Why should the taper on the male part of the joint be more gradual than that on the female part?**
4. **Explain the use of plumbers soil in making a wiping joint.**
5. **Why is tallow used on cleaned portions of the pipe?**
6. **Explain why the joint should not be moved until the solder has completely cooled.**
7. **What must be done if the solder hardens before the joint is completed?**

OPERATION NO. 5
TO WIPE A BREAK IN A LEAD PIPE

General Information

If an old joint breaks, or a section of lead pipe cracks, the break must be repaired in such a manner that the new solder will not run through the break and form obstruction-catching edges. In order to do this, a sheet-lead patch is wrapped around the break before it is wiped. Fig. 367.

Tools and Equipment

1. Plumber's furnace
2. Blowtorch
3. Wiping cloth
4. Melting pot
5. Ladle
6. Tin shears
7. Lead dresser
8. Rasp
9. Shave hooks
10. Paint brush

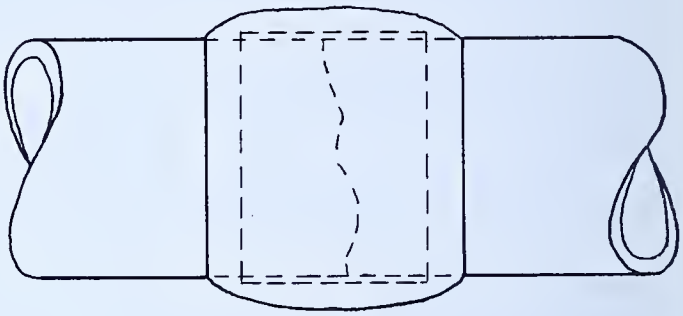


Fig. 367 — *Wiped Break*

Materials

Sheet lead 2″ x 12″
Wiping-solder
Tallow
Soil

Procedure

1. Place the broken pipe on vee blocks and secure it so the break cannot move.
2. Clean the pipe with the shave hook for a distance of 2″ from each side of the break.

   Paint plumbers soil around the pipe to limit the size of the joint. If the break occurred over an old joint melt off the old solder with a blowtorch.
3. Rub tallow on the cleaned surface.
4. Clean both sides of the piece of sheet lead.
5. Clean and test the solder in the melting pot.
6. Dip the patch of sheet lead into the solder to tin both sides.

   If the patch is too large to dip, hold the patch over the solder pot and pour molten solder over the patch with the ladle.
7. After the patch has cooled sufficiently to be handled by hand, wrap the patch around the pipe, centering it with the break.

8. Tap the patch tightly about the pipe with the lead dresser.

9. Cut off the patch so that the ends fit together.

10. Heat the pipe slightly with the blowtorch.

11. Fill the ladle with solder and pour slowly over the patch while holding a wiping cloth under the patch about ½" from the pipe.

    Work the solder with the cloth to form the joint.

12. Pour solder over the patch from side to side until the solder starts running off the patch into the cloth, then start wiping from the bottom to the top.

    The first and fourth fingers will have to be used to guide the patch into forming the edges of the band. The second and third fingers remain relaxed.

13. When the solder becomes a bit stiff, finish from the bottom to the top on one side and then on the other side.

    Keep the solder soft by using a blow torch while wiping.

QUESTIONS

1. **What is the fundamental purpose of placing a patch over the break before the joint is wiped?**

2. **Why must the pipe be cleaned before it is wiped?**

3. **Why is the patch tinned before it is placed around the break?**

4. **What must be done if the break occurs in an old joint?**

OPERATION NO. 6
TO WIPE A CUP JOINT

General Information

This joint is not as strong as a regular wiped joint. It is used only in cases where the pipes stand in a vertical position, or in extremely close quarters where it is impossible to get the hand around the pipe to make a regular wipe.

Tools and Equipment

1. Turnpin
2. Mallet
3. Rasp
4. Shave hook
5. Plumber's furnace
6. Blowtorch
7. Melting pot
8. Ladle
9. Wiping cloth

Materials

Wiping-solder
Tallow
Wire

Procedure

1. Flare out the bottom piece of pipe at the female end by using the turnpin and the mallet.
2. Taper the end of the upper piece of pipe with a rasp.

   This taper should be more gradual than that in the female end so that sweating space will exist between the male and female parts. Fig. 368.
3. Clean out the inside and outside of both pipe ends.

   Rub tallow on the cleaned parts to prevent oxidation.

Fig. 368 — *Male End*

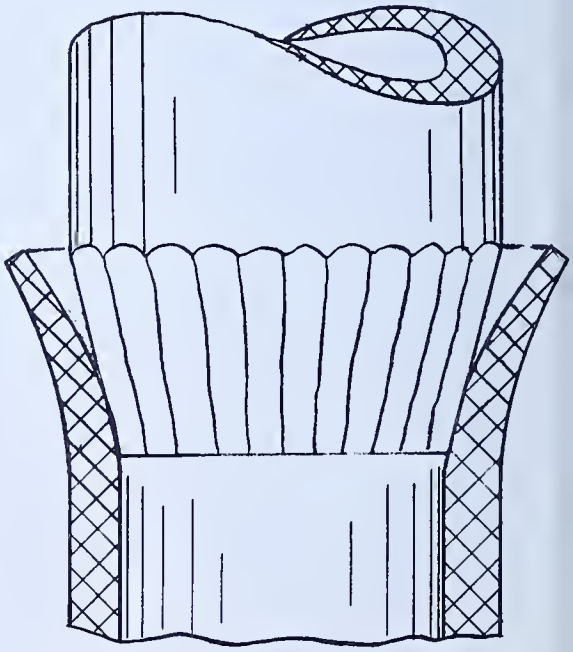


Fig. 369 — *Cup Joint Ready for Wiping*

4. Set the pipes in place, Fig. 369, and wire them fast.

   This provides a more rigid arrangement than that of having a helper hold the pipes. The pieces may not move until the solder has set. Hot or very warm solder is crystalline and is extremely brittle.

5. Test the solder for proper temperature and mixture.

   Clean the solder.

6. Heat the pipe with the blowtorch.

7. Dip out a ladle-full of solder and pour into the joint until full of solder.

8. Using the second finger on the wiping cloth, wipe the joint smooth.

   If solder cools before joint is completed, heat it with a torch and complete wiping.

QUESTIONS

1. **Is a cup joint as strong as a regular wiped joint?**
2. **How is the female part of the joint flared out?**
3. **Why should the two pipes be wired fast rather than be held in place by a helper?**
4. **Where can cup joints be used?**

OPERATION NO. 7
TO WIPE A FLANGE ON THE END OF A PIPE

General Information

This type of joint is used in making deck connections, bulkhead connections, and scupper valve (commonly called clapper valve) connections. Lead flanges (Fig. 371)

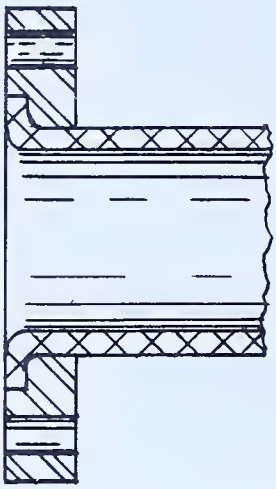


Fig. 370 — *Lead Pipe Flared into Steel Flange*

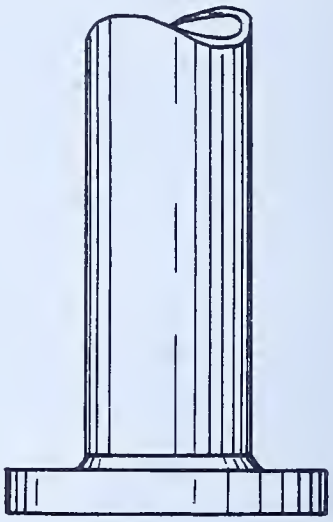


Fig. 371 — *Wiped Lead Flange*

are no longer used, but a repair job on old work might involve the use of a lead flange. At the present time steel flanges are used and the lead is flared and fitted over the recessed edge of the steel flange. Fig. 370.

Tools and Equipment

1. Plumber's furnace
2. Blowtorch
3. Melting pot
4. Ladle
5. Wiping cloth
6. Mallet
7. Shave hook
8. Turn pin
9. Rasp
10. Square
11. Paint brush

Materials

Wiping-solder
Tallow
Plumbers soil

PROCEDURE: LEAD FLANGE

1. Taper the end of the pipe that is to fit in the flange, starting about one inch from the end and $\frac{1}{8}''$ deep.
2. Smooth the tapered end with a shavehook, and coat with tallow.

   Paint soil around pipe above cleaned part.
3. Rasp a $\frac{1}{8}''$ bevel in the center hole of the flange on the pipe side of the flange.
4. Smooth out the bevel with the shavehook and coat with tallow.
5. Place the flange over the prepared end of pipe.
6. Insert the turnpin in the tapered end of the pipe until the pipe end is flared tightly against the inside of the flange.

   The end of the pipe should be flush with the face of the flange.
7. Check the solder for correct temperature and composition.

   Clean the solder.
8. Place the flange down, with the pipe standing straight up away from the floor.
9. Heat the flange and pipe with the blowtorch.

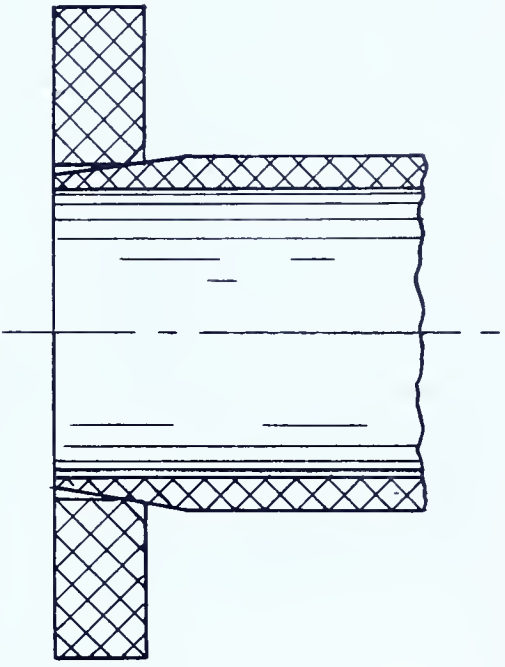


FIG. 372 — *Pipe Inserted into Lead Flange*

10. Fill the ladle with solder and pour around the joint until the joint is full.
11. Use the second finger on the wiping cloth to wipe the joint smooth.

    If the solder cools before the joint is completed, heat with a blowtorch until the solder becomes pliable.

QUESTIONS

1. **Where are flanged lead pipe connections used?**
2. **What type of flange connections are now used on lead pipe?**
3. **How is the pipe end fitted tightly in a lead flange?**
4. **How are the pipe and flange held in position for wiping?**
5. **Why is it necessary to test the solder for correct temperature?**

OPERATION NO. 8
TO WIPE A 1½″ BRASS CLEANOUT INTO A LEAD ELBOW

General Information

Cleanouts are used in all 90° elbows so that the piping section will not have to be dismantled in order to clean out any stoppage that may occur. By using cleanouts, the straight runs between bends or elbows may easily be cleaned. When wiping this job, a large sheet of paper should be placed on the floor under the elbow to catch the solder that will drip from the joint. A wiping cloth large enough to cover the entire hand must be used.

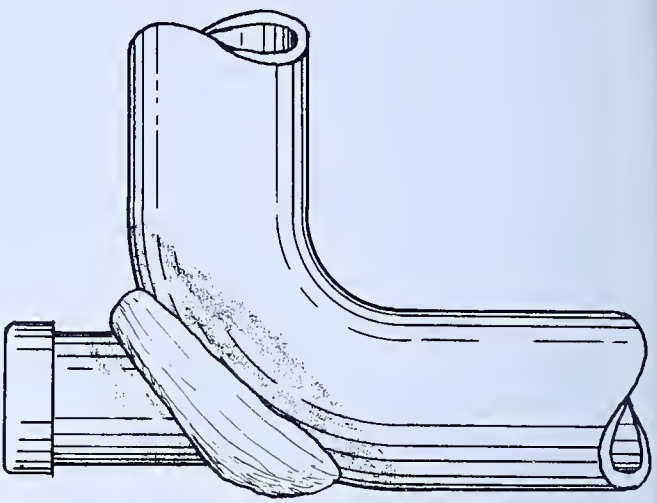


Fig. 373 — *Cleanout Wiped into Elbow*

Tools and Equipment

1. Tap borer
2. Mallet
3. Straightedge
4. Turn tool
5. Pliers
6. Plumber's furnace
7. Melting pot
8. Ladle
9. Wiping cloth
10. Rasp
11. 1½″ brass nipple
12. 1½″ brass cap
13. Soldering iron
14. Hack saw
15. Torch
16. File
17. Paint brush
18. Dividers
19. Hammer

Materials

Wiping-solder
Solder paste
Tallow
Plumbers soil

Procedure

1. Place the lead elbow on a bench and by placing the straight edge along the center of the run, mark the location for the center of the cleanout on the heel of the elbow.

2. Using the center mark, scribe a one inch circle on the heel of the elbow with the dividers.
3. Use the tap borer to bore a one inch hole.
4. Heat the pipe with the blowtorch.
5. Using the turn tool and hammer, flare out the one inch hole so that a 1½″ nipple can be inserted.

   The flare will extend outward far enough so that the nipple can fit inside the flare without interfering with the flow through the pipe. See Fig. 374.

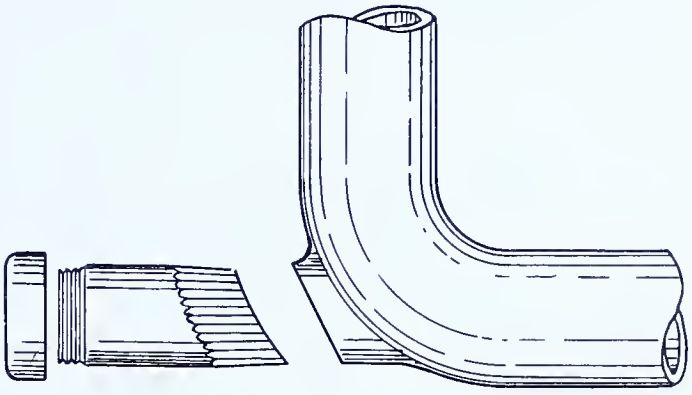


FIG. 374 — *Cleanout Disassembled*

6. Place the brass nipple inside the hole and mark the curve of the flare on the brass nipple.
7. Use a hack saw to cut off the brass nipple on this curved line.
8. File the outside of the nipple to clean it.

   Paint plumbers soil around nipple 1″ back from lead.
9. Apply soldering paste to the cleaned portion of the nipple.
10. Use the soldering iron to tin the nipple with 50-50 solder.
11. With the rasp, clean out the inside and outside of the flare. Smooth out all dents and scratches.

    Paint a 2″ band of plumbers soil one inch away from the flare. Set the dividers to 1″; then by holding one point against the flare a line may be scribed exactly 1″ from the flare.
12. Scrape the lead clean from the mark around the flare and apply tallow to the cleaned portion of the flare.
13. Insert the nipple into the flare and fasten it so that it is straight and will not move.

    A coupling turned on the end of the nipple and a short length of pipe turned into the coupling may be used as an aid in holding the nipple firm and straight.
14. Test the solder for proper temperature and composition.
15. Heat the brass nipple and lead elbow with the blow torch.
16. Fill the ladle with solder and pour over the joint, holding the wiping cloth about ½″ from the bottom of the joint.

17. Pour solder over the flared end and over the nipple, moving the ladle back and forth.

    As the solder runs to the bottom of the joint, catch with the cloth and bring it up the sides. Continue pouring until sufficient solder is on the joint, then start wiping, using the torch to keep the solder pliable.

18. Allow the solder to cool, then apply red lead to the threads and turn the brass cap tightly over the nipple.

QUESTIONS

1. **Why are cleanouts placed in lead elbows?**
2. **Describe the method of holding the nipple in place while the joint is being wiped.**
3. **Why is only a one-inch hole bored into the heel of the bend when a 1½″ nipple is to be used?**
4. **How is the mark made on the nipple for cutting it to the shape of the bend?**
5. **How is solder poured over the joint?**
6. **Why is the nipple tinned before it is inserted into the flare?**
7. **How is the solder kept pliable for wiping?**

OPERATION NO. 9
TO WIPE A VERTICAL JOINT BRANCH ON A 45° ANGLE

General Information

A branch is to be wiped into a vertical main 24″ from the clapper valve at a 45° angle on the side of the ship. The main is already in place when the branch is to be wiped in. See Fig. 375.

Tools and Equipment

1. Rasp
2. Mallet
3. Bending iron
4. Tap borer
5. Shave hook
6. Paint brush
7. Furnace
8. Melting pot
9. Ladle
10. Steel tape or folding rule
11. Blow torch
12. Wiping cloth
13. Cross cut saw
14. Dresser
15. Hammer

Materials

Plumbers soil
Tallow
Wiping-solder

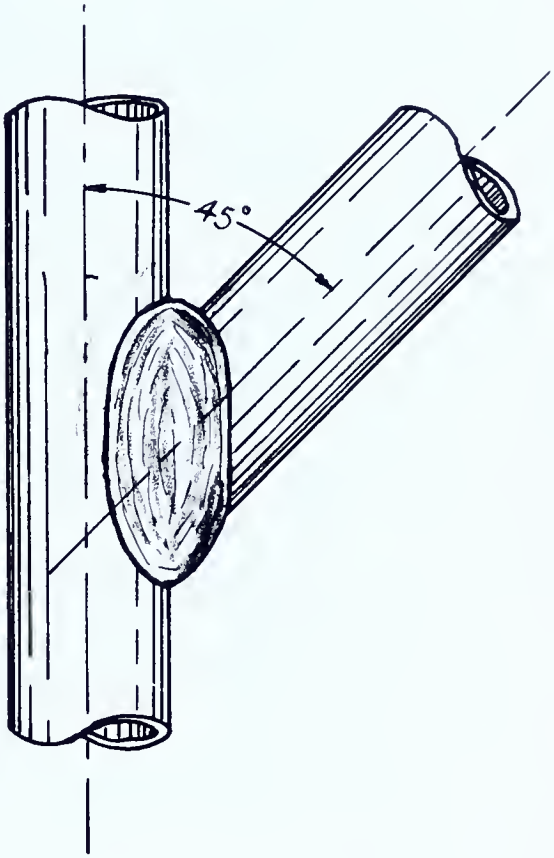


Fig. 375 — 45° *Branch*

Procedure

1. Take tools to ship and locate the line on which the branch is to be installed.
2. Use the rule to measure 24″ from the clapper valve to the center of the branch. Mark this point.
3. Locate the center of the pipe with reference to the center of the branch.
4. Scribe a 1″ circle around the center with the dividers.
5. With a tap borer or a lead knife cut a 1″ hole in the pipe over the center mark.

6. Insert the bending iron into the hole and flare out the edges by tapping the bending iron with a hammer.

   When flaring out the edges of the hole it must be remembered that the branch is to enter a 45° angle, therefore the flare must be made at a 45° angle. See Fig. 376.

7. Flare out the edges until a 4″ pipe will fit into the opening.

8. Saw off the branch pipe at a 45° angle.

9. Rasp off the end to fit the contour of the pipe.

10. Rasp a bevel on the shaped end.

11. Paint a 2″ band of plumbers soil around the pipe about 2″ from the end of the branch.

12. Clean about 2″ of the end of the branch with a shave hook, and tallow the cleaned area.

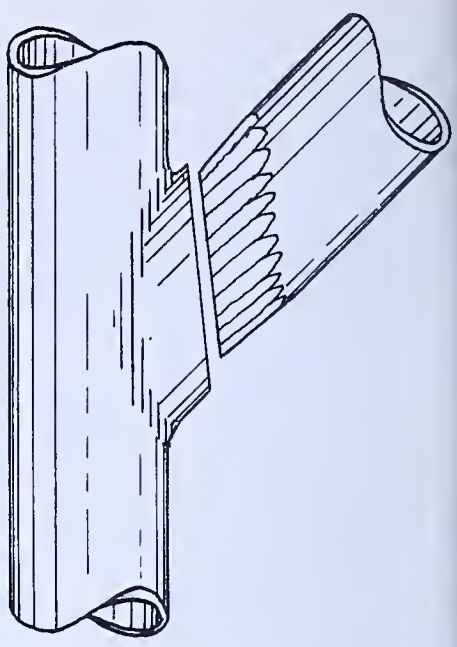


FIG. 376 — *Inserting Branch into Flare*

13. Paint a 2″ band of plumbers soil about 1″ from the flare around the opening in the main pipe.

14. Rasp the inside of the flare smooth, then clean with a shave hook and tallow the cleaned area.

15. Clean the outside of the flare and at least 1″ on the pipe around the flare with the shave hook, and tallow the cleaned area.

16. Fit the branch into the flare so that the edge of the branch will not interfere with the flow through the main pipe. Fig. 376.

17. Use the lead dresser or bending iron to tap the flare tight against the branch to prevent it from slipping down.

    Space must be left around the upper edge of the flare for sweating solder into the joint.

18. Fasten the branch pipe securely in place so that it will not move.

19. Check the branch for proper alignment and for the proper angle.

20. Test the solder for proper heat and composition. Clean the solder.

21. Heat the joint with the blowtorch.

22. Fill the ladle with solder and pour over the joint, holding the wiping cloth at the bottom of the joint to catch the lead that runs down over the sides.

    If there is insufficient space for pouring lead from the ladle, the solder will have to be splashed on the joint with a paddle.

23. After sufficient solder has been poured, proceed to wipe the joint.

24. While wiping, the solder may have to be heated with the blowtorch to soften it sufficiently for wiping.

25. Wipe the joint smooth, finishing the wiping at the top of the joint.

QUESTIONS

1. **What precaution must be observed when wiping in a branch such as the one shown in Fig. 375?**

2. **How is the opening in the main pipe flared out?**

3. **Is the branch end fitted tightly into the flare? Why?**

4. **How is the solder placed on the joint?**

OPERATION NO. 10
TO WIPE TWO HORIZONTAL BRANCHES ON 48″ CENTERS FOR TOILETS

General Information

A great deal of skill and patience is required to wipe joints. The branches must be properly aligned and held steady while the joint is being wiped. If the branch is not properly placed there may be an obstruction that will catch refuse and form a block in the main pipe. The branch must in no case extend down into the main pipe. The flare in the main must be carefully shaped so that the branch will fit snugly into the flare as far as possible without extending into the main. After the branch is located it must be held securely because a small movement in the branch when the solder is hot will cause the joint to crack or to weaken.

Tools and Equipment

1. Rasp
2. Tap borer or knife
3. Mallet
4. Bending iron
5. Shave hook
6. Plumber's furnace
7. Blow torch
8. Paint brush
9. Dividers
10. Melting pot
11. Ladle
12. Tap borer
13. Wiping cloth
14. Folding rule or steel tape
15. Hammer

Materials

Plumbers soil
Tallow
Wire
Wiping-solder

Procedure

1. Measure the necessary distance for the location of the first center to the end of the pipe and mark this position on the pipe.
2. Measure 48″ from this center to locate the position for the next center. Mark this position.
3. Locate the center of the pipe and with dividers scribe a circle around the center marks for gauging the flare (size of the branches).
4. Use the tap borer to bore 1″ holes on the center marks.
5. Insert the bending iron into the hole and flare out to the mark made by the dividers by tapping the iron with a hammer. Figs. 377 and 378.
6. Cut off the risers to the necessary length.

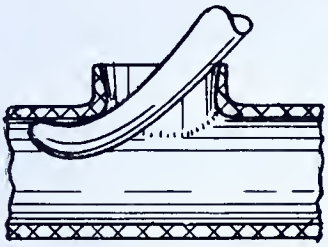


FIG. 377 — *Flaring Out Holes in Main Pipe*

FIG. 378 — *Plumbers Soil Painted Around Flare*

7. Rasp one end of each of the risers to saddle over a 4″ pipe.
8. Paint the ends with plumbers soil.
9. Use a shave hook to clean the prepared ends for a distance of about 2″ from the end.
10. Coat the cleaned ends with tallow.
11. Rasp the inside of the flares to fit the risers and paint with plumbers soil, a 2″ band 1″ away from the flare. Fig. 378.
12. Use shave hook to clean the inside of the flares.
13. Tallow the inside of the flares.
14. Place one of the risers into the flare and locate properly. See Fig. 379. Wire the riser rigid if possible.
15. Beat the flare against the riser with the bending iron until the riser is held securely and will not slip down into the pipe

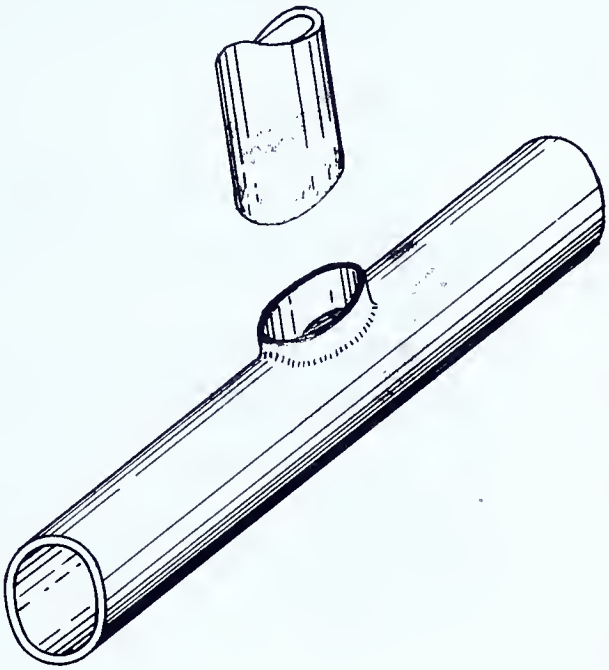


FIG. 379 — *Inserting Branch into Main*

16. Clean and test the solder.
17. Heat the pipe and joint with the blowtorch.
18. Dip out a ladle-full of solder and pour around the joint.
19. The cloth will have to be used while pouring to build up the solder for the joint.
20. When the solder has been placed about the joint, wipe the joint smooth.

It will be necessary to use a blowtorch on the joint to maintain sufficient heat for wiping. Fig. 380.

21. Proceed to fasten and wipe the second riser in the same manner, being careful to align the second riser with the first.

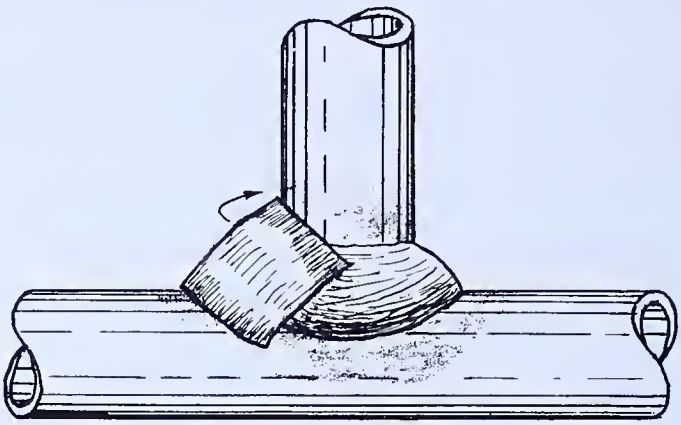


FIG. 380 — *Wiping Horizontal Branch*

QUESTIONS

1. **Why is it essential to place the branches very carefully on the main pipe?**
2. **Describe the method of preparing the openings in the main pipe to receive the risers.**
3. **How is the pipe marked so that the correct size of flare will be obtained?**
4. **How should the risers be secured before they are wiped to the main pipe?**

OPERATION NO. 11
TO LINE A BATTERY BOX

General Information

The battery box, located on the wheelhouse top of tankers, is lined with lead to prevent rust and corrosion of the box. A single piece of sheet lead is cut and bent to form a box that fits the inside of the steel battery box. Fig. 381. Sheet lead from

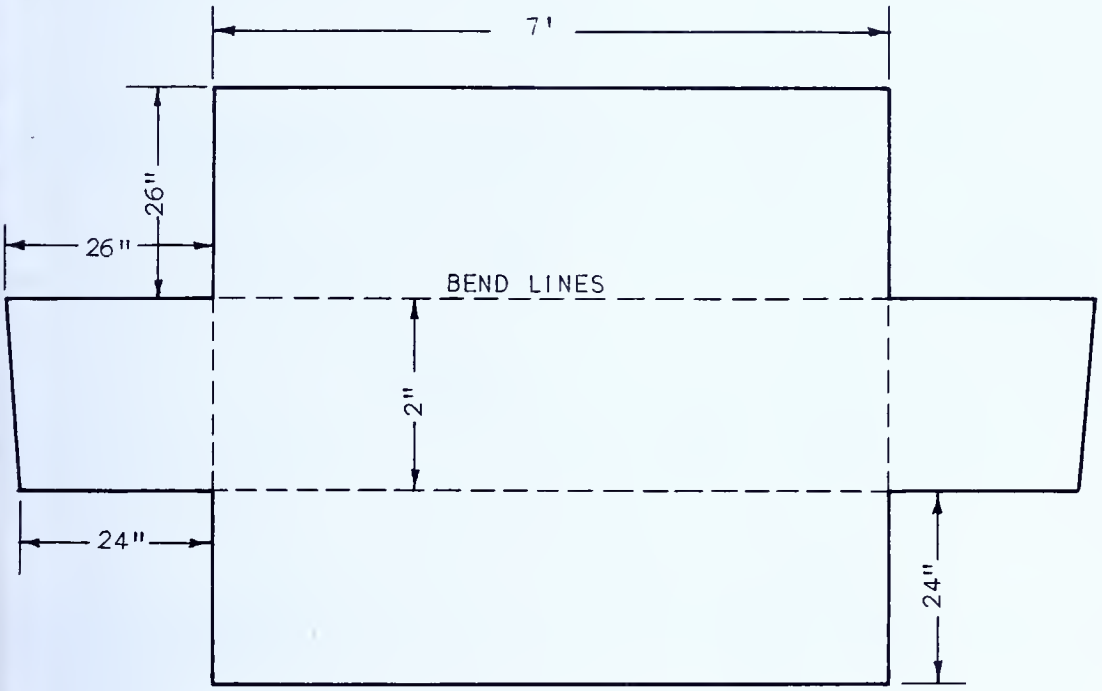


Fig. 381 — *Sheet Lead Cut to Fit Battery Box*

1/16" to ⅛" thick is used for the job depending upon the specifications. Sheet lead is obtained in rolls 6' to 8' wide and 20 ft. long. 1/16" sheet lead weighs about 4 lb. per square foot, and ⅛" sheet lead weighs about 8 lb. per square foot.

Tools and Equipment

1. Gasoline furnace
2. Blowtorch
3. Melting pot
4. Ladle
5. Wooden paddle
6. Wiping cloth
7. Paint brush
8. Dividers
9. Edging tool
10. Lead dresser
11. Lead knife
12. Tin shears
13. Mallet
14. Hammer
15. File
16. Soldering iron

MATERIALS

Wiping-solder	Solder paste
Tallow	50/50 solder
Plumbers soil	

PROCEDURE

1. Obtain complete measurements of the inside of the box.

   Make a rough layout on a piece of paper and mark down all the dimensions. Fig. 381. Height of back, height of front, width of box, and length of box, are the dimensions needed.

2. Obtain a piece of sheet lead the proper thickness and size.

   The length needed will be twice the height of the back plus the length of the box. The width needed will be the height of the back plus the width of the box plus the height of the front. The sheet might be cut out an inch or two larger than the exact amount needed to allow for trimming.

3. Lay the sheet flat on the floor and mark the sides, ends and bottom on the lead as shown in Fig. 381.

4. Cut out the corners with the lead knife or tin shears.

5. Tap lightly along the bend shown in Fig. 381 and hammer lines with the edging tool, being careful not to cut the lead.

6. Bend up the sides, front and back along the bend lines until they form a box.

7. Have three workers help lift the lead into the steel battery box.

8. With the lead dresser beat the lead against the sides and bottom of the box until it fits tightly all around.

9. Paint with plumbers soil along the sides of the corners for a space of 3″ to 4″.

10. Set the dividers to 1″.

11. Place one point of the dividers in the corner and scribe a line 1″ from the corner on both sides.

12. Proceed to mark off all corners in the same manner.

13. Use the shave hook to scrape the lead clean in each corner up to the marks made by the dividers.

14. Rub tallow on the cleaned areas.

15. Test and clean the solder.

16. Heat a corner with the blowtorch.

    The lead rests against the cold steel box and will harden solder quickly. Care must be taken not to melt the lead.

17. Holding the ladle-full of solder in the left hand and the paddle in the right, carefully splash solder on the joint.

    Start from the bottom and work upward. The solder will run down the seam and will have to be pushed up with the paddle from time to time.

18. When sufficient solder has been splashed on the joint, pour the solder back into the pot and lay the ladle and paddle aside.

19. Hold the blow torch in one hand and the wiping cloth in the other and heat the solder until it can be wiped.

20. Start wiping from the bottom, using only the first two fingers to wipe.

21. Pressure is used on the sides to wipe away any excess solder that may be on the side.

    The solder may have to be heated frequently until the wipe is completed.

22. After the wipe is completed proceed to wipe the next corner in the same manner.

23. After all the joints are wiped, trim off the lead even with the top of the box.

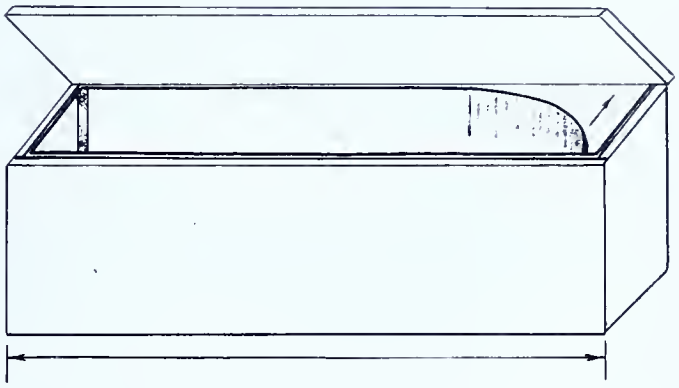


FIG. 382 — *Lined Battery Box*

The top will then be soldered to the box. To solder the lead lining to the steel box, clean the top edges of the steel with a file and apply soldering paste. Heat the soldering iron and melt 50-50 solder on the edge of the steel. Hold the soldering iron on the solder until it melts and joins the lining with the steel. Slowly move the soldering iron along the edge and solder the lining to the top edge of the box. The soldering iron will have to be heated frequently for this job. (See Fig. 382.)

QUESTIONS

1. What measurements are required for laying out the sheet lead box?
2. How is the sheet lead cut?
3. How is the lead box fitted tightly against the steel battery box?
4. How is solder placed on the joints?
5. What must be done to wipe the joints?
6. How is the lead box fastened to the steel box?
7. Why must soldering paste be used to fasten the lead to the steel box?

APPENDIX I

SHIPBUILDING TERMS AND THEIR DEFINITIONS

A

ABEAM — At right angles to the keel.

ACCESS HOLE — A hole through casing, bulkhead, floor or deck to enable one to reach work or gear.

ACCOMMODATION LADDER — Stairs slung at the gangway.

AFT, AFTER — Toward the stern or rear of ship. Between the stern and the midship section of a vessel.

AFTER BODY — That part from midship to the stern or rear.

AFTER HATCHWAY — The hatchway nearest the stern.

AFTER PEAK — A compartment just forward of the stern post. It is generally almost entirely below the load water line.

AFTER PEAK BULKHEAD — The bulkhead at the stern next to the after peak; always watertight.

AFTER PERPENDICULAR — A vertical line at right angles to the base line at a point designated by the architect.

AIR CASING — A ring-shaped plate coaming surrounding the stack and fitted at the upper deck, just below the umbrella. It protects the deck structure from heat and helps ventilate the fire room.

AIR PORT — An opening in the vessel's side or deck house for ventilation.

ALOFT — Above the deck.

AMIDSHIP (S) — In longitudinal, or fore and aft center of a ship. Halfway between stem and stern (front and rear).

ANCHOR — An iron implement for holding a ship at rest in water by means of a fluke or hook which grips the bottom.

ANGLE — The point where two lines meet. Sometimes used as a shorter term for angle iron.

ASSEMBLE — To collect or put into place different parts.

ATHWART — Across, from side to side: transverse; at right angles to the keel.

ATHWARTSHIP — At right angles to the keel. Same as abeam.

AUXILIARY FOUNDATIONS — The supports for pumps, condensers, distillers, etc.

B

BALLAST TANKS — Tanks carried in various parts of a ship for water ballast, to keep the vessel on an even keel.

BASE LINE — A horizontal level line at the lowest point of the mold lines and the top of the keel plate.

BATTEN — A narrow strip of wood for fairing lines. Also a strip of wood to fasten objects together.

BEAM — The extreme width of a ship. Also a transverse horizontal member supporting a deck.

BED PLATE — A structure fitted for support of the feet of the engine columns, as well as to provide support for crankshaft bearings. It also helps distribute engine weight and stresses to the ship's structure. The bed plate consists of a series of transverse girders, connecting fore and aft members of girders.

BILGE — The rounded portion of a vessel's shell which connects the bottom with the sides.

BILGE KEEL — A fin fitted on the bottom of a ship at the bilge to reduce rolling. It commonly consists of a plate running

fore and aft attached to the shell plating by angle bars. It materially helps in steadying a ship and does not add much to the resistance to propulsion.

BILGE PLATE — Any plate in a bilge strake.

BITTS — Iron fixed on any deck, for belaying of hawsers, warps, ropes, etc.

BOAT CHOCKS — Frames fitted upon deck conforming to the shape of the bottom of the boat which is bedded in it.

BODY PLAN — A plan consisting of two half transverse elevations or end views of a ship, both having a common vertical center line, so that the right-hand side represents the ship as seen from ahead and the left-hand side as seen from astern. On the body plan appear the forms of the various cross sections, the curvature of the deck lines at the side, and the projections as straight lines of the water lines, bow and buttock lines and the diagonal lines.

BOILER CASING — A wall protecting the different deck spaces from the heat of the boiler room.

BOILER ROOM — That part of the ship where the boilers are placed, connected with boiler hatch to top deck.

BOLSTER PLATE — A piece of plate adjoining the hawse hole, to prevent the chafing of the hawser against the cheeks of a ship's bow. A plate for support like a pillow or cushion.

BOOBY HATCH — The cover of a scuttleway or small hatchway such as that which leads to the forecastle or forepeak.

BOOM, CARGO — A boom extending from the mast like a derrick arm, to handle cargo.

BOOM REST — A saddle in which the boom is lashed down and made fast.

BOOM TABLE — A platform built up of channels, plates, and angles around both masts about on a level with the bridge. The cargo booms swivel on this table.

BOSOM — The inside of an angle bar.

BOSS — Any protuberance on parts. For example: The boss on the stern casting, is the part through which the propeller shaft runs.

BOSS FRAME — A frame bent to allow room for the stern tube, or tail shafts in the case of twin-screw ships.

BOSS PLATE — A curved plate covering (one on each side) the boss of a propeller post and the curved portion of frames in way of the stern tube of a screw steamer. This plate is of extra thickness.

BOTTOM PLATING — That part of the shell plating which is below the water line.

BOW — The front or forward end of a ship.

BOW PLATE — Any of the shell plates in the bow of a ship.

BRACKET — A steel plate, commonly with a reinforcing flange, used to stiffen or tie beam angles to bulkheads, frames to longitudinals, etc.

BREADTH — The side to side measurement of a vessel at any given place. The ends of cross beams are considered the outward breadth measurements.

BREADTH, EXTREME — The width of a ship, including the thickness of plates.

BREADTH, MOLDED — Measured amidships at its greatest breadth to outside of frames.

BREAST BEAM — The beam in the poop and forecastle decks, the beams nearest the amidships from the decks.

BREAST HOOK—A triangular shaped plate fitted between decks connecting panting stringers in the bow for the purpose of rigidly fastening the stem and shell plating.

BRIDGE — A partial deck extending from side to side of a vessel amidships. It is common in steam vessels, affording a convenient station for the officer in command. It is also known in England as the hurricane or bridge deck.

BRIDGE HOUSE — The erection or superstructure fitted about amidship on the upper deck of a ship The officers' quarters, staterooms and accommodations are usually in the bridge house.

BRIDGE, LONG OR CAT WALK — On tankers, a narrow walk connecting forward deck house to after deck house. On large passenger ships, a bridge having considerable length fore and aft.

BROW — A small curved angle or flanged plate fitted on the outside of the shell of a ship over an air port to prevent water running down the ship's side from entering the open port.

BROW OR BROW PLATE — A plate forming a riser on the port and starboard and fore and aft sides of 'tween deck hatches. It makes possible trucking cargo up on the 'tween deck hatch cover so that it can be hoisted through the shelter deck cargo hatch.

BUCKLED PLATE — A plate warped in or out, making it out of line; a plate thicker at the center than at the edges.

BULB ANGLE — An angle bar with its long leg terminating in a bulbed toe.

BULKHEAD — A watertight partition extending from the double bottom to the top main deck, so constructed that in case of accident in one compartment, damage is confined to that compartment. A partition in a ship which divides the interior into various compartments.

BULKHEAD (LONGITUDINAL) — A partition wall of plating running in a fore and aft direction.

BULKHEAD, FOREPEAK — The bulkhead farthest forward, generally called the collision bulkhead.

BULKHEAD (TRANSVERSE) — A partition wall of plating running in an athwartship direction across a portion of the whole breadth of a ship.

BULWARK — A term applied to the strake of shell plating above a weather or shelter deck. It helps to keep the deck dry and also serves as a guard against losing cargo or men overboard.

BUNKER — A compartment in which fuel is stored.

BUOYANCE — The capacity for floating which a vessel possesses.

BUTTOCKS — The traces formed by the intersection of longitudinal vertical plane of the ship, with the forward and after surface of the ship's hull. These traces when occurring in the fore body are called bow lines and in the after body buttock lines. However, the term buttocks is often used to denote both bow and buttock lines.

BUTT JOINT — A joint made by fitting two pieces squarely together on their edges, which is then welded or butt strapped.

BUTT STRAP — A plate to connect two plates or bars together at the ends.

C

CALK — To tighten a lap or other seam with a chisel.

CAMBER — The athwartship curvature of decks, etc. The weather decks of ships are rounded or arched in an athwartship direction for the purpose of draining water to the sides of the ship where it can be led overboard through scuppers. In brief, the camber is the crown or arch of a weather deck.

CANT — A term signifying an inclination of an object from a perpendicular; to turn anything so that it does not stand perpendicularly or square to an object.

CANT BEAM — Any of the beams supporting the deck plating or planking in the overhanging part of the stern of a vessel. They radiate in fan shape from the transom beam to cant frames.

CANT FRAMES — The frames (generally bulb angles) at the end of a ship which rise obliquely from the keel.

CARGO HATCH — An opening in a ship's deck for the loading and discharging of any kind of cargo.

CARGO PORT — A large opening in a vessel's side through which cargo is passed on and off.

CASING — The extra case or bulkhead built around the ship's funnel, engine room, or boiler room to protect the surrounding parts from heat.

CENTER LINE — The fore and aft line at the middle of the ship.

CENTER LINE BULKHEAD — A bulkhead running from the forepeak or collision bulkhead to the afterpeak bulkhead, except in the engine space. The neutral center of the center line of the ship.

CHAIN LOCKER — The compartment, near and below the hawse holes at the bow, for stowing the anchor chains.

CHAIN PIPE — A pipe of large diameter, through which the chains pass into the chain lockers.

CHALK LINE — A small line, strong enough to withstand being drawn very taut over a surface. The line is first chalked, then drawn taut between two points and "snapped", thus leaving an impression of the chalk on the surface to be marked.

CHECK LINE — Used in shaping plates, etc., to make sure that the templates have not changed in size by shrinking, expanding, or warping.

CHOCKS — Deck fittings for mooring line to pass through.

CLEAT — A piece of wood used to belay ropes.

COAMING — A frame bounding a hatch for the purpose of stiffening the edges of the opening and forming the support for the cover. It also prevents any water on deck from washing down to the deck below through the companionway.

COAMING — Plates, heavier than bulkhead plates, at the top and bottom of deck houses, bulkheads, and division bulkheads between decks, for the purpose of stiffening and adjusting height to suit the shape of the ship.

COFFERDAM — A void or empty space separating two or more compartments from entering another in case of a leak.

COLLAR — An angle ring used around a pipe or mast, or a flat plate made to fit around a girder or beam passing through a bulkhead or deck. It serves to make various spaces watertight, oiltight, weathertight, or dusttight.

COLLISION BULKHEAD — A watertight bulkhead at the forepeak extending to main deck. This bulkhead prevents the entire ship from being flooded in case of a collision.

COLUMN — A pillar or stanchion.

COMPANIONWAY — A set of steps or ladder leading up to deck from below.

COUNTER — The overhang of the stern aft of the stern post.

COUNTERSINK — A hole tapered so that a rivet, bolt, or screw head will come flush with the surface of the material.

CRIBBING — Timbers used to support bottom of ship while it is under construction.

CROSSTREE — A structure on the mast built up of plates and angles for the purpose of holding the shroud pads.

CROW'S NEST — A platform and protective coaming setting on the crosstree on the foremast, to accommodate the look-out aloft while the ship is at sea.

D

DAVITS — A set of cranes or radial arms on the gunwale of a ship, from which are suspended the lifeboats.

DEAD FLAT — The midship portion of a vessel throughout the length of which a constant shape of cross-section is maintained.

DEAD RISE — The angle which the straight portion of the bottom floor of the midship section makes with the base line. It is expressed by the number of inches rise above the base line in the half-breadth of the vessel.

DECK — A deck in a ship corresponds to the floor in a building. Decks are named or numbered by the architect designing the ship and bear these names and numbers from that time on.

DECK BEAM — A beam which supports a deck.

DECK BEAM STRINGER PLATE, DECK STRINGER PLATE, DECK BEAM STRINGER — A plate stringer placed on the seam ends of any deck; the stringers take their names from the beams of the various decks on which they are laid.

DECK-BRIDGE — A partial deck extending from side to side of ship about amidships.

DECK-FORECASTLE — A partial deck at bow of ship, raised above weather deck.

DECK, HURRICANE OR BOAT DECK — The uppermost deck; deck where boats are stowed.

DECK HOUSE — A small house erected upon the deck of a ship for any purpose.

DECK LINE — The line from forward to aft where a deck touches the ship's side.

DECK, LOWER OR ORLOP DECK — The first deck above tank top.

DECK, MAIN — The deck at the top of the main body frames. Above the main deck the frames are smaller and lighter in weight.

DECK PLAN — A drawing showing the layout of a deck.

DECK PLATING — Plates covering deck beams and thus forming an iron steel deck.

DECK, POOP — The raised deck on the after part of a ship.

DECK, PROMENADE—A deck above upper deck, set aside for use of first-class passengers on passenger ships.

DECK STRINGER ANGLE BAR OR GUNWALE BAR — An angle bar used to secure stringer plate of any deck to shell plating.

DECK TRANSVERSALS — See deck beams.

DEEP FLOORS — Floors in the fore and aft ends of a vessel, so called on account of their greater depths.

DEEP TANKS — These usually consist of ordinary hold compartments but strengthened to carry water ballast. They are placed at either side or both ends of the engine and boiler space. They usually run from the tank top up to, or above, the lower deck.

DEEP WATER LINE — The line to which a vessel is submerged with a full cargo on board.

DEPTH, MOLDED — Measured amidships from the top of keel to the top of beam at the upper deck.

DISPLACEMENT — Total weight of ship while afloat, including everything aboard.

DISTORTION — The result of excessive strains that cause a plate or a form to lose its proper shape.

DOGS — Holding devices used on doors, hatch covers, air ports and other hinged parts of a ship.

DONKEY ENGINE — An auxiliary engine to operate the lifting apparatus on deck.

DOUBLE BOTTOM — A tank whose bottom is formed by the bottom plates of a ship, used to hold water for ballast, for the storage of oil, etc.

DOUBLER PLATE — An extra plate of the same strength or stronger than the original plating for additional strength.

DRAUGHT MARKS — The stern and stem are marked in feet to show the draught or depth of the vessel.

DRIFT PIN — A small tool used to draw adjoining parts in line so that the rivet holes will coincide.

DRY DOCK — A dock into which a vessel is floated, which when raised lifts the boat out of the water.

E

ENGINE ROOM — Where the engines of a ship are confined, next to the boilers.

ERECTION — The process of hoisting into place and bolting up the various parts of the ship's hull, machinery fittings, etc.

F

FABRICATE — To shape, assemble, and secure in place the component parts in order to form a complete whole. To manufacture.

FAIRING A LINE — Straightening lines supposed to be straight or smoothing out into a smooth curve, lines supposed to be curved.

FANTAIL — The upper and round part of the stern. The frames or cants are arranged like the tail of the famous breed of pigeons, fantail.

FATHOM — Six feet; a marine unit for measuring depth.

FIDLEY DECK — A partially raised deck over the engine and boiler rooms, always around the smokestack.

FILLET — Where two surfaces meet, forming a corner; any material in the corner to partially fill it is a fillet. Usually the fillet is concave.

FLARE — The spreading out from the central vertical plans of the forebody of a ship with increasing rapidity as the section rises from the water line to the rail.

FLAT — A term applied to a partial deck built without any camber.

FLAT KEEL — The bottom center line plate of the ship.

FLOOR — A plate placed vertically in the bottom of a ship on every frame and running athwartship, from bilge to bilge.

FLUSH DECK — A deck whose top side is flush.

FLUSH HEAD RIVET — A rivet, the head of which does not extend above the surface of the plate, angle bar, etc., in which it is driven.

FORE AND AFT — In line with the ship's keel; fore and aft deck line girders.

FOREBODY — That part from the amidships to the front of stem.

FORECASTLE — Crew's quarters on the forward part of the ship generally below the main deck on cargo ships and above the main deck in tankers.

FORE, FORWARD — Toward the stem or front. Between the stem and amidships.

FORE PEAK — The narrow extremity of vessel's bow. Also hold space within it.

FORE RAKE — The forward part of the bow which overhangs the keel.

FORWARD PERPENDICULAR — A vertical line perpendicular to the base line at a point designated by the architect. Usually frames start numbering from the forward perpendicular, which is the zero frame.

FOUNDATION PLATE, SOLE PLATE — A plate to which an engine or pump, etc., is bolted. A plate forming part of a foundation.

FRAME ANGLE BARS — The angle bars of which a frame of any kind is constructed.

FRAME HEAD — The section of a frame that rises above the deck line.

FRAMES — The ribs of a ship.

FRAMES, CANT — A group of frames (cant frames) extending over the rubber forming the stern of the ship; frames not at right angles to the keel.

FRAMES SPACING — The distance between frames.

FRAMES, REVERSE — Angles at top of floor plates; angle forming part of a frame, but in a reversed position to the angle joining the shell plating.

FRAMES, SIDE — Frames in the side above and connecting with the margin plates.

FREEBOARD — The distance from the water line to top of bulwark, amidships.

FUNNEL — A large sheet iron tube, extending from the uptake high above the deck, through which the smoke and gases pass.

FREEING PORT — An opening in the bulwark or rail for discharging large quantities of water, when thrown by the sea upon the ship's deck. Some ships have what they call "swing gates" which allow water to drain off but which automatically close from the pressure of sea water.

G

GALLEY — The kitchen of a vessel.

GALVANIZING — The process of coating one metal with another, ordinarily applied to the coating of iron or steel with zinc. The chief purpose of galvanizing is to prevent corrosion.

GANGPLANK — A board with cleats forming a bridge reaching from a gangway of a vessel to the wharf.

GANGWAY — The opening in the bulwarks of a vessel through which persons come on board or disembark. Also a gangplank.

GARBOARD — The plating next to the flat keel, or what is known as strake A.

GEAR, STEERING GEAR, RUNNING GEAR, CLEANING GEAR, ETC. — A comprehensive term used in speaking of all the implements, apparatus, machinery, etc., which are used in any given operation.

GIB — A metal fitting that holds a member in place, or presses two members together.

GIRDER — A heavy supporting beam.

GOOSENECK — A return, or 180 degree bend, having one leg shorter than the other. An iron swivel making up the fastening between a boom and a mast. It consists of a pin and an eyebolt, or clamp.

GRATING — An open iron lattice work used for covering hatchways and for forming a platform in engine room, stair landings, etc.

GROMMET — A ring of candle wicking used as a washer or gasket around bolts and studs to make a watertight joint.

GUNWALE — The line where a shelter deck stringer meets the shell.

GUNWALE BAR — An angle on the deck connecting both deck and shell. Pronounced gunnel.

GUSSET PLATE — A tie plate, used for fastening posts, frames, beams, etc., to other objects.

GUTTER, WATERWAY — The gutter or runway between the gunwale and gutter angle bars, forming a channel for water to run to deck scuppers.

GUYS — Wire or hemp rope or chains to support booms, masts, davits, etc.; guys are employed in pairs. Where a span is fitted between two booms, for example, one pair only is required for the two.

H

HALF BEAMS — Short beams extending from a machinery or boiler casing or from the hatch side coaming to the side of the ship.

HALF-BREADTH PLAN — A plan of one-half of a vessel, divided by a center line drawn through the stem and stern posts. It shows the water, bow, and buttock lines.

HATCH BARS — The bars by which the hatches are fastened down.

HATCH BATTENS — Thin strips of wood fitted tight against the coamings to hold the hatch covering or tarpaulin in place.

HATCH COVERS — Covers for closing up hatchways.

HATCH STRONG BACK — A member built up of plates and angles to provide a support for the hatch cover.

HATCHWAY — One of the large square openings in the deck of a ship through which freight is hoisted in or out, and access is had to the hold. There are four pieces in the frame of a hatchway. The fore and aft pieces are called coamings and those athwartship are called head ledges. The head ledges rest on the beams and the carlings extending between the beams. There may be forward, main and after hatchways, according to the size and character of the vessel.

HATCHWAY COAMING — Vertical plates forming the border around a hatchway.

HAWSE — That part of a ship's bow in which are the hawse holes for the anchor chains.

HAWSE HOLE—A hole in the bow through which a cable or chain passes. It is a cast steel tube, having rounded projecting lips both inside and out.

HAWSE PIPE — A cast steel pipe connected to the hawse hole running from the shell to the deck, for chains to pass through.

HAWSER — A cable used in warping and mooring.

HEADER — A bar or angle under a deck the same size as deck beams. It is used around stair openings in deck, small hatch openings, or at dead end of longitudinals.

HEEL — The intersecting point or corner of the web and flange of a bar.

HOLD — The rudder, steering wheel and tiller.

HOLD — An interior part of a ship, in which the cargo is stored. The various main compartments are distinguished as the forward, main, and after holds, or by numbers such as 1, 2, 3, 4, etc.

HOLD FAST — A dog or brace to hold objects rigidly in place.

HULL — The body of a vessel, not including its masting, rigging, etc.

I

I BEAMS — Steel beams with cross section like the letter "I".

INBOARD — From the side to the center of ship.

INNER BOTTOM — The top of a double bottom. The tank top.

INTERCOSTALS — Plates which fit between floors, frames, or beams, as stiffeners.

INTERMEDIATE BEAMS — Beams placed between deck beams, if the spacing of the latter is unusually large.

INTERMEDIATE FRAMES — Those frames in a cellular double bottom to which no floor plates are connected.

J

JACK LADDER — A ladder with wooden steps and side ropes.

JACOB'S LADDER — A rope ladder with wooden rounds.

K

KEEL — The "backbone" of a ship. A series of connected plates running fore and aft on the bottom of the center line of the ship.

KEEL BLOCKS — Blocks on which the keel of a vessel rests when being built, or when she is in dry dock.

KEELSON — A vertical strake of plates on the keel at the center line, running fore and aft from stem to stern. It is sometimes called the center line girder or center keelson.

KING POSTS — The main pillar posts of the ship. Also called Samson post. A post or pillar forming support for a cargo boom.

KNEE — An angle or channel from deck beam to shell frame taking the place of a bracket.

KNOT — A unit of speed equivalent to one nautical mile, or 6080.26 feet (1.15156 statute miles), an hour. The term is sometimes carelessly used to mean a nautical mile; the knot, however, is a rate of speed and not a distance.

L

LADDER — Inclined or vertical steps on board ship taking the place of "stairs".

LANDING STAIRS — Tread on stairs enlarged to form a platform.

LAP — A joint in which one part of a plate overlaps another, thus avoiding the use of a butt strap.

LAUNCH — To place a vessel in the water, after completion.

LAYING OFF — Marking plates, bars or shapes for shearing, punching, bending, and identification from a template or print.

LAY OUT — To develop on a working surface, lines to their true dimensions.

L.B.P. (LENGTH BETWEEN PERPENDICULARS) — Measured from the forward perpendicular to the after perpendicular.

LIFT A TEMPLATE — To construct a template to the same size and shape as the part of the ship to be duplicated.

LIFTING — Transferring marks, shapes, and measurements from a ship drawing, or model, to a plate or other object, by means of templates.

LIGHTENING HOLES — A hole cut in a plate to make it lighter and yet not reduce its strength. Sometimes large enough to be called a manhole.

LIGHT LOAD LINE — The water line when the ship rides empty.

LIGHT PORT — An opening in a ship's side, provided with a glazed lid or cover for the admission of light.

LIMBER HOLES — Holes in the bottom of floors for drainage, or at the top of floors for gas to escape.

LINER — A piece of flat steel which may or may not taper to a feather edge. Used to fill out a lap or to form a middle layer between two objects. Also for leveling foundations.

LIST — If one side of a vessel lies deeper in the water than the opposite side, caused by the shifting of cargo, etc., it is said to list.

L.O.A. (LENGTH OVER ALL) — Measured from the most forward part of the fore end to the most after part of the after end of the hull.

L.W.L. (LOAD WATER LINE) — A line painted on the side of the vessel to which the vessel sinks when carrying its full load. The water line when a vessel is carrying its full load.

LOCKER — A storage compartment in a ship.

LOFT — See mold loft.

LOFTSMAN — A man who lays out the ship's lines in the mold loft and makes the molds and templates.

LONGITUDINAL — A bulkhead, frame, or longitudinal stiffener, running fore and aft.

LOWER DECK OR ORLOP DECK — The deck next above the tank top.

M

MAIN BEAM, LONGITUDINAL — The two largest beams supporting a deck between which are cargo hatches.

MAIN BEAM, TRANSVERSE — Large beams at hatch ends, same size as longitudinal main beams.

MAIN BODY — The hull proper, without deckhouse, etc.

MAIN BODY FRAMES, MAIN FRAMES — Frames below the main deck of a vessel.

MAIN BREADTH LINE — The greatest width of a ship. If a ship's sides tumble home, the main breadth line will be at the point where the tumble home begins.

MAIN DECK — The principal strength deck in a ship, atop the heaviest or main frames.

MAIN DECK STRINGER INNER ANGLE BAR OR WATERWAY BAR — An angle bar forming inner side of waterway.

MAIN DECK STRINGER OUTER ANGLE BAR OR GUNWALE BAR — An angle bar connecting main deck stringer to shell plating.

MANHOLE — A hole in a tank, boiler or compartment on a ship, designed to allow the passage of a man for examination, cleaning, and repairs.

MAST — A hollow steel pipe or tube made up of plates and doublers tapering smaller at the top, placed on the center line of the ship.

MESSROOM — A dining room on a ship.

MIDSHIP — The vertical transverse section located at the mid point between the forward and after perpendiculars. Usually this is the largest section of a ship in area.

MITER — To match angles; an angled cut made for a joint.

MOORING LINES — Cables or hawsers used to tie up a ship.

MOORING — Securing a vessel in position by cables or lines.

MUSHROOM VENTILATOR — A short cast iron tube having a movable iron rod passing through its center. On top of the rod is fixed a round metal cup, which may be lifted to admit air, or closed to prevent water entering tube, usually fitted over cabins.

N

NAUTICAL MILE — The 60th part of an equatorial degree, equal to about 6,080 English feet; therefore 6 nautical miles represent 7 English miles, approximately.

NAVIGATION BRIDGE — The bridge used for taking observations, or directing the handling of the ship.

O

OAKUM — A material made of tarred rope fibers, used for calking seams in a wooden deck.

OFFSET — To bend out of line sharply. The points given by the draftsman to the loftsman for putting down lines.

OILTIGHT — Packed and calked to prevent flow or waste of oil.

ON BOARD — On or in a ship.

ORLOP DECK — The lowest deck in a ship having four decks, or lower deck. See deck, lower.

OUTBOARD — Used to designate from the center to the sides of a ship.

OUTBOARD PROFILE — A plan representing the longitudinal exterior of a vessel, showing a side of the shell, all deck erections, masts, yards, rigging, rails, etc.

OUTER SKIN — The outside plating of a vessel.

OUTSIDE PLATING — See Shell Plating.

OUTSIDE STRAKE, OVERLAPPING STRAKE — A strake of plating which overlaps inside strakes with its upper and lower edges.

P

PEAK TANK — Tanks in the forward and after ends of a vessel. The principal use of peak tanks is in trimming the ship. Their ballast is varied to meet required changes in trim. Should the after hold be empty, the vessel would ride so high that the propeller would lie half out of water and lose much of its efficiency. Filling the after peak tank, forces the propeller deeper into the water.

PINTLE — A tapered metal pin which fastens the rudder to the stern post and affords an axis of oscillation as the rudder is moved from side to side for steering.

PITCH — The distance between the center of two contiguous objects, such as teeth of a wheel, etc.; also the distance a screw propeller would advance in one revolution if turning in a steadfast medium.

PLAY — The difference between the diameter of a shaft, rod, etc., and that of the hole in which it works.

PLIMSOLL LINE — The mark stencilled in and painted on a ship's side, designated by a circle and horizontal lines to mark the highest permissible load water lines under different conditions.

PONTOON — A portable tank used to give buoyancy.

POOP — The structure or raised deck at the after end.

POOP BULKHEAD — A bulkhead placed at the fore end of a poop between the shelter deck and the poop deck.

POOP DECK BEAMS — The beams on which a poop deck is laid.

POOP DECK WATERWAY — The space between the gunwale and the gutter angle bars on a poop.

POOP LADDER — A ladder leading from a shelter to a poop deck.

POOP RAIL — A rail surrounding the poop deck.

PORT — An opening in a vessel's side, in a bulwark, etc., used for various purposes.

PORT HOLE — An opening in the ship's shell plating.

PORT LID — A shutter for closing a port hole in stormy weather.

PORT SIDE — The left-hand side of a ship looking forward toward the bow or stem.

PRICK PUNCH — A small punch with a keen point used to transfer the holes from the template to the plate.

PROFILE PLAN — The side elevation of a ship's form.

PROPELLER — The means by which a vessel is driven through the water.

PROPELLER ARCH — The arched section of the hull above the propeller.

PROPELLER BLADE FLANGE — A flange on blades that are bolted to propeller boss.

PROPELLER BOSS — The hub to which removable blades are bolted.

PROPELLER SCREW — A propeller so called because blades are at an angle to line of axis, similar to the thread of a screw.

PROPELLER SHAFT, TAIL SHAFT — The shaft to which the propeller is keyed or fastened.

PROW — The part of the bow extending from the load water line to the top of the bow.

PUNCHED RIVET HOLE — A rivet hole made by a punching machine.

Q

QUARTERS (OF A SHIP) — Living space for the crew.

QUICKEN — To shorten the radius of a curve; as, to quicken a sheer is to make it more pronounced.

R

RACK — A shelf, framework, etc., in which objects are secured to prevent them from moving about.

RAIL — A guard made of flat pieces of wood, or steel bars or rods, joined, and connected to the upper edge of the bulwark plating, or fitted upon the summits of stanchions surrounding an upper deck, bridge, poop, or forecastle, etc.

RAIL STANCHIONS — The iron stanchions, about 3 feet high, placed about the same distance apart, fitted with several tiers of guard ropes or chains, to enclose the sides and ends of a bridge, forecastle or poop, and sometimes an upper deck.

RAISED QUARTER DECK — A structure interrupting the after portion of a shelter deck, raised several feet above it, extending from side to side of vessel.

RAKE — The inclination of a vessel's mast, funnel, stem, etc., from its upright angle with the keel. The rake may be either forward or aft. The elevation of the out end of a bowsprit above the level of its inner end.

REAMING — Using a reamer to make rivet holes fair and smooth on the inside.

RECESS BULKHEAD — A bulkhead of any recessed portion of a hold or compartment.

RECESS OF TUNNEL — The elevated and extended portion of a tunnel. (At the after end such an enlargement of tunnel is called "stuffing box recess", while at the forward end it is known as "thrust recess.")

REDUCTION GEARS — The gears that reduce turbine speed to propeller speed. They constitute an important part of a turbine installation and may be located forward or aft of the turbines. The reduction is generally made in two stages.

RESERVE BUOYANCY (OF A VESSEL) — The lifting power. It may be measured by the volume of watertight hull above the load water line.

REVERSE FRAME — An angle bar with its heel against another angle to give the other angle additional strength.

RIBBAND — Strips of material temporarily holding parts of a ship in position.

RIDER FRAME — Any frame riveted or welded on another frame for the purpose of stiffening it.

RIDER PLATES — Plates set on top of the center keelson. The strake of plates at the center line of each deck.

RIGGER — One whose occupation is to rig or unrig vessels, take up or down the yards, etc.

RIGGING — Manila and wire ropes, lashings, etc., used to support booms, masts, spars, etc. Also, handling and placing heavy weights and machinery.

RISER — A vertical plate between steps in a stairway.

RIVET — A metal pin by which the plating and other parts of iron and steel vessels are joined. Rivets are known by their heads, such as: Flush, pan, snap, plug, tap, countersunk, mushroom, and swollen neck.

RIVET HOLES — The punched or drilled holes in plating, frames, etc., into which the rivets are driven for connection.

RIVETING — To fasten with rivets.

ROLLER CHOCKS — Chocks with a short vertical roller fixed to ease a line passing through.

RUDDER — A swinging vane, built up of casting and plates, hung to the stern post of a ship, by which the ship is steered.

RUDDER ARM — "L" shaped casting flanged to rudder stock forming an arm to control the rudder.

RUDDER POST OR RUDDER STOCK — That portion of the rudder casting bearing the gudgeon eyes or "hinge ears" and the rudder flange.

RUN — The narrowing of a vessel's after bottom.

S

SAGGED — When from some cause a vessel's form is so altered that the ends of the keel are much above the level of its midship portion, it is said to be "sagged".

SCARPH — A lapped joint made by beveling off, or otherwise cutting away the sides of two plates at the ends. (Also spelled scarf).

SCREEN BULKHEAD — An arrangement to prevent the cold air from striking the boilers directly.

SCREW PROPELLER — A propeller having blades or paddles set at an angle and having a pitch like a screw thread which, when driven by a shaft, forces the vessel to move.

SCUPPER PIPE — Pipe connected to deck scupper to allow water to run below decks, to prevent waste water flowing down the sides of ship.

SCUPPERS — Openings in the shell plating just above deck plating to allow water to run overboard.

SCUTTLE — A small hatch.

SEAM — The line where the edges of plates meet when joining each other.

SECTION — A drawing representing the internal parts of a vessel as if she had been cut straight through, either longitudinally or athwartships.

SHAFT ALLEY — A watertight passage, housing the propeller shafting from the engine room to the bulkhead at which the stern tubes commence. It provides access to the shafting and its bearings and also prevents any damage to the same from the cargo in the spaces through which it passes.

SHAFT ALLEY TUNNEL — An enclosure of watertight construction, extending along the middle of engine room bulkhead on tank top to the stuffing box, at the after end. It contains the shaft which is elevated.

SHAFT, SPARE — An extra tail shaft. (Steamers generally carry one or more stowed in the shaft alley.)

SHAFT STRUT — A term applied to a bracket supporting the after end of the propeller shaft and the propeller in twin or multiple screwed vessels having propeller shafts fitted off from the center line.

SHEER — The upward curvature of the lines of a vessel toward the bow and stern.

SHEER PLAN — A vertical longitudinal center line section of a vessel.

SHELL — The outside plating of a ship from stem to stern.

SHELL DOUBLING OR DOUBLER — An extra plate added to strengthen the shell.

SHELL PLATING — The plating forming the outer skin of a vessel.

SHELTER DECK OR WEATHER DECK — The top deck of a vessel reaching from shell to shell.

SHIM — A piece of metal or wood placed under the bed-plate or base of a machine or fitting for the purpose of truing it up.

SHIPFITTER — A mechanic who makes templates; marks, assembles, and fastens plates and shapes in place. He should be able to do any fitting on ship.

SHORE — One of the many wooden props by which the ribs or frames of a vessel are externally supported while building, or by which the vessel is held upright on the ways.

SHORING — The act of supporting anything by shoring it up.

SHROUD PADS — Devices for attaching shrouds or guy cables to crosstree and bulwark.

SKELETON (OF A VESSEL) — The hull without the outside and inside plating.

SKIN — The plating of a ship.

SKYLIGHT — A framing of metal fitted over an opening in a deck, with window glass inserted for the admission of light into a cabin, engine room, etc.

SLIDING WAYS — A structure of heavy timbers placed between ground ways and cradle to support the ship during launching.

SLUICE — An opening in the lower part of a bulkhead fitted with a sliding watertight gate or door having an operating rod extending to the upper deck or decks.

SOFT PATCH — A plate put on over a break or hole, and secured with stud bolts. It is made watertight with a gasket such as canvas saturated with red lead.

SOUNDING PIPE — A pipe leading from main deck to double bottom of sufficient size to allow a round piece of metal attached to a line to be lowered to ascertain the amount of liquid in the double bottom.

SPOT-FACED — Indicates that an annular facing has been made about a bolt hole to allow a nut or head to seat evenly.

STAGE — A platform of boards or planks, hung in ropes or otherwise supported for a person to stand upon when cleaning, scraping, or painting the outside or inside of a vessel.

STAGGER — To zigzag a line, or row of rivet holes, etc.

STANCHION — A pillar or iron post for supporting the decks, etc.

STARBOARD SIDE — The right-hand side, looking from aft forward.

STEALER OR STEALER PLATE — A plate taking two strakes used near either end of the ship.

STEERAGE — The after part of a vessel having the poorest accommodations and occupied by the steerage passengers, or those paying the lowest fare.

STEERING GEAR FLAT — The deck above the stern overhang, on which the rudder steering mechanism is installed.

STEM — The bow of the ship, the part where the port and starboard meet up forward.

STERN — The after or rear end of the vessel.

STERN CASTING OR FRAME — A heavy steel casting or forging at stern of vessel supporting the rudder and to which the shell plate strakes are fastened.

STERN TUBE — The bearing which supports the propeller shaft where it emerges from the ship. A cast steel cylinder, fitted with brass bushings

which are lined with lignum vitae or metal bearing surfaces, upon which the propeller shaft, enclosed in a brass sleeve, rotates.

STIFFENER — An angle bar or stringer fastened to a surface to strengthen it and make it rigid.

STOPWATER (IN RIVETED SHIPS) — A packing of felt or canvas and red lead to prevent water from passing through metal parts where calking is impracticable.

STRAKE — A continuous row of plates.

STRINGER — A longitudinal stiffener for the side of a ship, made of angle bar, bulb angle channel or plates, etc. Depending upon their locations, stringers are known as bilge stringers, side stringers, hole stringers, etc.

STRINGER PLATE — The outboard strake of plates next to the shell.

STRONG BACK — A bar for locking cargo port doors and watertight scuttles.

STRONG BACK — A portable bar to hold hatch covers and deck loads.

STRONG BEAM OR TROLLEY BEAM — A portable beam over engine and boiler room space in the engine and boiler room casing carrying a traveling hoist.

STRUT — Strips of flat iron used to brace one part with another.

SUNK POOP — A poop set part way down into the 'tween decks. In a case of this kind, the poop deck is but a little above the next deck forward.

SUPERSTRUCTURE — Any structure built above the top full deck, such as a deck house, bridge, etc.

SWASH BULKHEADS — Longitudinal or transverse bulkheads fitted in a tank to decrease the swerving action of the water. Their function is greatest when the tanks are partially filled. Without them the unrestricted action of the liquid againts the sides of the tank would be severe.

SWASH PLATE — A plate fitted in a tank to retard the flow or surge of liquid cargo or ballast when the ship rolls or pitches.

SYMBOLS — Marks of identification.

T

TAIL SHAFT — The aft section of the shaft which receives the propellers.

TANKS — Are of two kinds: First, those built in permanently and part of the ship's structure, used for the reception of water ballast, fuel, oil, or liquid cargo; second, those constructed specially and removable if necessary. These vary greatly in size and shape and the purpose for which used.

TANK TOP — The plating laid on the floors of a ship, which forms the top side of the tank sections or double bottom.

TANK VESSEL (TANKER) — A vessel specially constructed and equipped with tanks for carrying liquids in bulk.

TAP — To cut threads inside of a hole. A tool for tapping.

TAUT — Stretched tight.

TEE IRON, TEE BAR — Bar iron with cross section like the letter "T".

TEMPLATE — Patterns made in the mold loft from wood strips, cardboard, or heavy paper.

TEMPORARY BULKHEAD — A bulkhead fitted for temporary purposes.

TIPPING BRACKETS — Flat bar or plate brackets placed at various points on deck girders, beams stiffeners, or longitudinals as reinforcement.

TOE — The edge of a flange or a bar.

TONNAGE — A measure of a vessel's interior volume.

TRANSOM FRAME — The last transverse frame of a ship's structure. The can frames, usually normal to the round o the stern, connect with it.

TRANSVERSE — Placed at right angles to the keel, such as a transverse frame, transverse bulkhead, etc. See also abeam and athwart.

TRANSVERSE BULKHEAD — A bulkhead placed athwartships.

TREAD — A step in a stairway.

TRIMMING TANKS, PEAK TANKS — Tanks at the extreme ends of a vessel. By filling or emptying one or the other, a ship may be easily trimmed by the head or stern as required.

TRUCK PLATE — A flat plate fitted to the stern post and flanged to take strakes of stern plating.

TURBINE — A form of engine in which all driving parts rotate. There are various types in marine use.

'TWEEN DECKS — The space between any decks.

U

UPPER WORKS — Superstructures, or deck erections located on or above the weather deck. Sometimes used with reference to a ship's entire above-water structure.

UPTAKE — The part connecting smoke box to funnel. Sometimes the term is used to include the smokebox.

V

VENTILATOR — A device for furnishing fresh air to compartments below deck, or exhausting foul air.

VERTICAL CENTER KEELSON, VERTICAL KEEL — A keelson of strong vertical plates fitted at the center line upon the keel and to which the (half) floor plates are connected by welding or by vertical angle bars.

W

WALKWAY OR CAT WALK — Used on oil tankers. An elevated runway from poop to midship, and midship to forecastle deck. It affords means of safe passage for crew members when deck is awash in stormy weather.

WATER BALLAST — Sea water used for ballast, let into the double bottom, or into a water-ballast tank, or trimming tanks.

WATER BALLAST TANKS — Tanks in the double bottom used for ballast.

WATER LINE (LIGHT) — The line to which a vessel is submerged without cargo on board.

WATER LINE (LOADED) — The line to which a vessel is submerged with full cargo.

WATER LINES — Lines drawn parallel with the surface of the water at varying heights on a ship's outline. In the sheer plan, they are straight and horizontal; in the half-breadth plan they show the form of the ship at each of the successive heights marked.

WATERTIGHT BULKHEAD — A bulkhead that will not let water pass from one side of it to the other.

WATERTIGHT COMPARTMENT — A compartment having a watertight bulkhead at each end.

WATERWAY — A gutter at the edge of a deck for draining water to scuppers.

WATERWAY BAR OR GUTTER ANGLE BAR — An angle or flat bar attached to a deck stringer plate forming the inboard boundary of a waterway and serving as an abutment for the wood deck plating.

WAYS — The frame work of timber, etc., on which a vessel is built, from which she is launched into the water.

WEATHER DECK — A deck exposed to the wind and sea, i.e., not fully covered by a deck above and with side plating coming up to it.

WEB — The plate or its equivalent in a beam or girder, which connects the upper and lower flat plates, or laterally extending members.

WEB FRAME — A frame built up transversely with a plate or plates to give greater stiffness.

WEDGES — Tapered pieces of wood or iron, used extensively to force parts into place.

WEEPING — When water oozes through the seams of a vessel's shell, or a steam boiler, etc., they are said to weep.

WELDING — Connecting two separate pieces of steel, iron or other metal with a gas flame or an electric arc, so that they become all one piece.

WHEEL HOUSE — A house over the wheel.

WINCH — A machine used for loading and discharging cargo, or for hauling in lines.

WINCH HEAD — A drum (usually of small diameter and concave) on a winch, designed for taking and holding the turns of a rope

WINDLASS — A special form of winch used to hoist the anchors. It has two drums designed to grab the lines of the anchor chains and is fitted with ratchet and braking device suitable for "paying out" chain.

WING TANKS — Tanks formed by shell and bulkheads, not reaching to center line bulkhead.

APPENDIX II

PIPEFITTING TERMS AND THEIR DEFINITIONS

A

After-fill Tube — See refill tube.

Air Chamber — An extension of the water piping beyond the branch to fixtures terminating with a cap. The compressed air in this portion of piping prevents any shock or vibration of pipe if faucet is closed suddenly.

Air Test — Test applied to piping work after the entire job is completed. This is a very rigid test.

Angle Valve — A globe valve whose openings or tappings are at an angle of 90°.

Anneal — Process of removing the temper or hardness of metal by heat.

Armstrong Joint — A two bolt, lugged or flanged connection for high pressure.

B

Back-water Trap — A trap with a check or flapper valve which prevents sewage backing up in the drain line.

Ball-cock — Supply valve in tank, operated by a copper ball or float.

Ball Joint — A connection consisting of a ball within a shell, which allows freedom of swing in all directions.

Basin Wrench — A wrench which has the jaws at right angles to the handle. Used to connect basin cock couplings.

Battery — Series, as a battery of three lavatories.

Bell Trap — A trap formed by an inverted cup extending into a circular trough or ring of water. Used in ice boxes and decks aboard ship.

Bending Pin — Tool used by plumbers to swedge out opening in lead pipe made by tap borer.

Bibb — Generally called faucet. It has either a hose or plain end.

Bi-transit Waste — Sometimes called standing overflow. Used on bath and lavatory wastes.

Block Tin — Tin in its pure state. Used in making soft solder. When a strip is bent, it gives off a crackling sound.

Bolt — A bolt is threaded on one end only, the other end being upset to form a head.

Bolt-stud — A bolt stud is threaded on either or both ends, or full length to standard diameter for nut assembly on each end.

Boiler Tube — A tube extending from the cold-water inlet of range boiler to within 6″ of the bottom of the boiler. It prevents the entering cold water mixing with the hot water which accumulates at the top of the boiler.

Bonnet — The top part of a faucet or bibb, the removal of which is necessary to renew packing.

Bossing Stick — A wooden tool used to shape up sheet lead for tank lining.

Branch — The outlet or inlet of a fitting not in line with the run.

Briggs' Standard — Standard pipe thread as used on screw pipe in the United States.

Bull-headed Tee — A tee having a branch of larger diameter than the run.

Bushing — A reducing fitting with a male and a female thread.

By-pass — Independent connection around valve.

C

C. I. F. — Refers to cost, insurance, and freight.

C. W. W. — Cold Wash Water.

C. W. S. — Cold water supply.

C. D. W. — Cold Drinking Water.

Caliber — The internal diameter or bore of a pipe or fitting.

Cap — Fitting with female thread used to seal end of pipe.

Calking — The process of packing oakum and lead in the hub of cast-iron pipe.

Centrifugal Trap — A trap so constructed as to give the water when passing through it, a whirling motion, thereby making the trap self-cleaning.

Chain Tongs — A wrench used by plumbers in which the upper jaw of wrench is replaced by a chain.

Chase — A recess in wall in which soil, vent, and waste stacks or similar piping is installed.

Check Valve — An automatic valve which allows the flow of steam, water or air only in one direction.

Chipping Knife — Knife used by lead workers for cutting sheet lead.

Circulation Pipe — A return hot-water pipe from a fixture located considerable distance from the boiler. It insures hot water immediately when opening the faucet.

A return line from drinking fountain to scuttle butt on ships. Instant cold water is provided at the fountain. This saves water and keeps it from freezing in the scuttle butt.

Clapper Valve — See back water trap.

Cleanout Plug — A device placed on the drain or waste pipe to allow the use of a wire or cable to remove a stoppage in piping.

Close Nipple — A short piece of pipe on which the threads abut each other.

Closet Bolt — A brass bolt with nickel plated nut, used to secure a closet bowl.

Cock — See stop cock.

Companion Flange — A pipe flang suited to connect with another flang or fitting.

Compression Bibb — This type of bib requires several turns of a T-handle t open.

Coupling — A threaded sleeve for co necting two lengths of pipe, sometime called a sleeve.

C. P. — Chromium plated.

Cross — A fitting with four outlets 90° to each other.

Cross-over or Saddle Fitting — Use on screw-pipe where two pipes cross.

Cross-over T — A combination of a and a cross-over fitting.

Cup Joint — A joint used on lead pip made by opening end of pipe enoug to receive the tapered end of anothe piece.

D

Dead End — The end of any line of pip which has been extended beyond th last branch.

Deck Sleeve — See stuffing box.

Drifted — The operation of driving wooden plug through lead pipe of co responding size to remove dents.

Dutchman — A flange machined off both sides.

E

Ell — 90° fitting with female threads.

Escutcheon — Plate or shield which fi around pipe and against deck or bul head to hide rough hole.

Expander — Tool used for expansion boiler, tubes, and pipes.

Expansion Joint — Joint to relie strain, absorb vibration, compensa for change in length of pipe, etc.

F

Fifty-Fifty Solder — Solder made of half lead and half tin.

Fireline — Water supply line to f hose.

FITTING — Pipe connections, such as coupling, union valve.

FIXTURE — Plumbing unit, lavatory, shower head, sink.

FLANGE UNION — A pair of flanges, threaded to receive screw pipe, which can be bolted together with a gasket between, and made air tight.

Used on large pipe in place of ordinary union.

FLARE OUT — To swedge outward.

FLUSH BUSHING — Bushing having no shoulder, so as to allow it to screw into fitting and leave surface flush. Also called face bushings.

FLUX — A flux may be in liquid, paste or powdered form, and is used in soldering to prevent the heat of the soldering iron from oxidizing material to be soldered.

FOLLOWER — An attachment for threading devices, which insures the cutting of a straight thread. Somtimes called guide.

FULLER BIBB — This type of bibb is opened full by one-half turn of a lever handle, which operates stem by means of an eccentric.

FURNACE — Term applied to plumbers' gasoline or kerosene firepot.

G

GALLING — Tearing threads when cutting.

GALVANIZING — A coating of zinc applied to pipe or sheet iron to prevent corrosion.

GASKET — Washer or packing either of metal or rubber composition used in union or coupling.

GATE VALVE — A valve which has a double seat in the form of a V. When valve is closed, a metal wedge is forced into the V-seat closing the passage. It is practically the only valve opening to the full bore of the pipe.

GLOBE VALVE — A globular-shaped valve operating similar to a compression bibb.

GOOSE-NECK — A return of 180° bend generally of small tubing, having one long end.

GREASE TRAP — Special form of trap used under sink, so constructed as to prevent grease from entering sewer.

GROMMET — A ring of rope, used as a washer or gasket around bolts or studs to make a watertight joint.

GROUND JOINT — A tapered or beveled joint, generally of brass or copper, which requires no gasket or packing.

GUIDE — See Follower.

H

HALF Y — Fitting used in drainage work whose branch is at an angle of 30° to the run.

HARD SOLDER — Generally known as spelter and used in brazing. An alloy of copper and zinc. Melting point about 1,700° F.

H. D. W. — Hot drinking water.

HEADER — Term used to designate the main line pipe.

HUB — The large or receiving end of cast-iron pipe.

H. W. S. — Hot water system.

H. W. W. — Hot wash water.

HYDROSTATIC TEST — Test applied to "rough work" before job is covered, the entire system being filled with water and pressure applied with pump.

J

JOINT RUNNER — Asbestos rope used for pouring molten lead in horizontal joints of cast iron pipe.

L

LAP WELD — Method of making steel or wrought-iron pipe in which the edges of the sheet are beveled and lapped before welding.

LAVATORY — Wash basin.

LEAD (WHITE) — Oxide of lead mixed with boiled linseed oil. Used by plumbers for screw joints.

LEAD WOOL — Lead in a shredded form used to caulk cast-iron pipe where the moisture prevents the use of molten lead.

LOCK-BIBB — A bibb or faucet so constructed as to allow the use of a padlock to prevent its being opened.

LOCK NUT — A thin hexagonal nut generally used with long screw nipples.

LOCK-STOP — A stop cock so constructed as to allow the use of a padlock to keep it opened.

LONG SCREWS — A nipple 6 in. in length which has one of its threads several times the length of an ordinary thread.

M

MALE AND FEMALE — A term used by pipe fitters in referring to outside (male) and inside (female) threads.

MANIFOLD — A fitting with numerous branches used between a large pipe and several small pipes.

MUFFER — A brass sieve or strainer inserted in the inlet of a supply valve to eliminate the noise of rushing water when valve is opened.

N

NEEDLE VALVE — A valve whose stem terminates with a metallic needle point. Used on gas and oil appliances.

NIPPLE — A piece of pipe, 12″ or less, threaded on both ends.

NIPPLE CHUCK — A device for holding a nipple while thread is being cut on the other end.

N. P. Brass — Nickel plated brass.

O

OAKUM — Hemp saturated with oil, making it impervious to moisture.

ONE-EIGHTH BEND — Elbow changing direction of pipe 45°.

ONE-QUARTER BEND — Elbow changing direction of pipe 90°.

ONE-SIXTH BEND — Elbow changing direction of pipe 60°.

ONE-SIXTEENTH BEND — Elbow changing direction of pipe 22½°.

OPEN-TANK SYSTEM — Method of supplying water to the ship by gravity.

P

PET COCK — Small cock used for draining various appliances such as pumps, radiator cylinders, etc.

PIPE CUTTER — A tool with knife-edge wheels used to cut steel or iron pipe.

PIPE FITTING — Process of bending, cutting, threading, etc.

PIPE FITTINGS — Denotes various devices such as tee, ell, faucet, etc.

PLUG COCK — A stop consisting of a tapered plug, which fits accurately into the shell or body of cock. One-quarter turn of lever handle completely closes passage. Used on water, air, or gas.

PLUMBERS SOIL — A mixture of lamp black and glue used by lead workers.

PLUMBING — All work installed which has to do with the flow of liquids and gasses and the removal of sewage.

PLUNGER — A cup-shaped device of rubber for forcing stoppage in waste pipe. Commonly called plumbers' friend.

P. O. PLUG — Drainage connection which is screwed in lavatory. A pull out plug.

POP VALVE — A safety valve controlled by a spring, which can be adjusted to various pressures.

P-TRAP — A trap whose diameter is uniform throughout, the outlet being at right angles to the inlet.

R

RECEPTOR — A shallow fixture of porcelain or iron enamel, used with a shower.

REDUCER — Pipe fitting used to reduce diameter of pipe and join two pieces of pipe.

REFILL TUBE — A small brass tube in closet tank which discharges water through the overflow, thereby insuring closet trap being sealed after flushing.

RETURN BEND — A bend which reverses the direction of pipe or changes its course 180°.

RUN — A length of pipe that is made up of more than one piece of pipe.

S

SANITARY SEWAGE — Foul waste of human or animal origin, 99% of which is water.

SCUPPER PIPE — Pipe connected to scupper to allow passage of water, connected to run below decks to prevent waste water flowing down sides of ship.

SCUTTLE BUTT — Water cooler generally located in ice box or in ice machine room.

SERVICE ELL — An elbow of 45° or 90° having male thread on one end and female on the other. Also called a street ell.

SERVICE TEE — A tee having male thread on one end, the other end and the branch having female threads. Also called a street tee.

SEWAGE — The liquid and solid matter which flows through the drain.

SEWER AIR OR GAS — The air in drains caused by the decomposition of waste matter.

SHAVE HOOK — A small scraper used by lead workers to scrape lead pipes previous to soldering.

SHOULDER NIPPLE — A nipple having a space of ¼″ to ½″ between threads.

SHRUNK JOINT — A joint made by placing a heated circular piece of metal, as a piece of pipe, over a cool piece, the cooling of which causes it to shrink onto the cooler piece.

SIAMESE CONNECTION — A "Y" or fork connection used principally on fire-lines, whereby two lines of a hose may be attached to one valve or standpipe.

SILL-COCK — A compression type of hose bibb located on the bottom of a hot water tank to which a hose may be attached for drainage.

SKELP — The name given to the flat strip of metal before it is formed into a length of screw pipe.

SLIP JOINT — A connection generally used on nickel waste tubing. Candle wicking saturated in tallow, or a rubber ring, is used for packing.

SOCKET — A British term for coupling (See coupling).

SOCKET PLUG — A plug having a square socket or recess. A special wrench is inserted into socket to tighten plug.

SOFT SOLDER — An alloy of varying proportions of tin and lead, melting at from 375° F., to 440° F., according to proportions of tin and lead.

SOIL — See plumbers soil.

SOIL PIPES — This term is frequently used in referring to steel, lead, or cast-iron pipe, but applied only to such pipe when it receives the discharge of one or more waste water lines.

SOLDER — An alloy of two or more metals which fuses at a lower temperature than the metal which is to be soldered.

SOLDER JOINT — Joint made up by soldering; used in streamline work.

SPELLERIZING — The process of toughing wrought-steel pipe by running the skelp through corrugated rolls.

SPELTER — An alloy of copper and zinc used for brazing.

SPIGOT — See bibb.

STOCK — A threading tool which holds the dies.

STOP AND WASTE COCK — A device similar to the stop cock in action and purpose, but which allows all the water to stop to drain through a waste outlet in the side of cock.

STOP COCK — A device made of cast brass or iron, by which the flow of water, gas, or air is controlled. It consists of a tapered plug or core fitted

accurately into a casting, both of which have a hole through them to correspond to the diameter of pipe. One-quarter turn of handle entirely closes passage.

STREET ELL — See service ell.

STUD — A bar of steel threaded on both ends.

STUFFING BOX — Water tight gland used for making a water tight joint through bulkhead or deck. Also called stuff tube.

STREAMLINE PIPE — Refers to copper tubing. Joints and fittings are soldered.

SUMP PUMP — Scavenger pump used to clean out sumps.

SWEEP — Name applied to a fitting having a long turn.

SWEATING — A term used when the piping is covered with moisture caused by cold water passing through pipes which are located in a warm room.

SWEEP FITTING — Any fitting having a long, easy turn.

SWEAT JOINT — A joint made by means of a flame, instead of soldering iron.

SWING JOINT — A connection in screw-pipe work to take care of expansion.

SYPHON — The action caused by a vacuum on one side of a trap and the atmosphere on the other.

SYPHON-JET CLOSET BOWL — The better type of closet bowl having a small hole, at the bottom of trap, through which a jet of water is discharged into trap thereby assisting in the syphonic action of bowl.

SYPHON WASHDOWN — Popular type of closet bowl having no jet, but depends on the volume of water to create syphonic action.

T

TAIL-PIECE — That part of a coupling over which the loose nut is placed.

TANK NIPPLE — Nipple 6″ long having standard taper pipe thread on one end; the other end has a standard taper pipe thread running into an American Standard Locknut thread for a total length of 4″.

TAP — A tool used for cutting female threads, as in fitting, valves, etc.

TAP BORDER — Tool used by plumbers to make opening in lead pipe for branch joint.

TAPPED T — A cast-iron fitting with hub, having a branch tapped for screw pipe.

TEMPLATE, TEMPLET — Layout or pattern.

THERMOSTAT — An automatic device operated by the expansion and contraction of metal or liquid, and used to close types of valves at desired temperatures.

TIN LINED PIPE — Pipe of brass, iron, copper, or lead, with a layer of block tin on the inside making it non-corrosive.

TRAP — A device holding water which prevents the passage of air in either direction but will allow a free passage of all various liquids.

TUBING — Light-weight pipe, generally of brass, steel, or copper. Measured on the outside.

TUCKER FITTING — A galvanized cast-iron fitting, one end of which is threaded to receive screw pipe, the other end being a hub for cast-iron pipe.

T-Y — A fitting used in drainage work, whose branch is 90° to the run.

U

UNDERWRITERS APPROVED — Term applied to material bearing approval of underwriters.

UNION — A three piece device used to connect pipes.

URINAL — A toilet-room fixture intended for men's use. Flushed by tank or direct pressure.

V

VACUUM — A space devoid of all matter.

VALVE — A device placed in pipe line or wherever desired to control the flow of liquids, air, or gas. It is operated by several turns of a wheel handle.

VITREOUS WARE — Earthen-ware dipped in molten glass and subjected to intense heat in kilns.

VENT — Pipe to top of boat to relieve vacuum on soil lines.

W

WASHOUT BOWL — This type of closet bowl is practically obsolete and is very unsanitary, having a large fouling surface and depending on the force of water to cleanse it.

WASTE STACK — The vertical line of pipe 2″ or over which receives the discharge of all fixtures other than water closets.

WATER-BACK COUPLING — A ground-joint connection in piping at the range which allows water back to be removed without cutting pipe.

WATER CLOSET — Toilet bowl.

WATER HAMMER — The shock caused by the sudden closing of a bibb or cock. It is overcome by the use of an air chamber.

WIPED JOINT — A solder joint made by plumbers or cable splicers with the use of a wiping cloth. Solder used is 65% lead and 35% tin.

WIPING CLOTH — A pad made of herring-bone ticking or mole-skin cloth. Material is folded so as to make a pad of 16 thicknesses.

WYE — A fitting used in drainage work whose branch is at an angle of 45° to the run. Usually called a "Y".

Y

YOKE — A name given to the collar by which lead trap is secured to the sink.

APPENDIX III

ABBREVIATIONS USED IN SHIPBUILDING

A.A. — Anti-Aircraft
A.B.S. — American Bureau of Standards
Abv. — Above
A.Cant. — After Cant Frames
A.D. — After Draft
Adj. — Adjustable
A.E. — Air Escape
Aft.B. — After Body
A.G. — Armor Grating
A.L. — Accommodation Ladder
Al. — Aluminum
Alt. — Alteration
A.M.C.B.H. — Auxiliary Machine Casing Bulkhead
Amm. — Ammunition
A.P. — After Perpendicular; Air Port or Porthole
Arrgt. — Arrangement
A.S. — Air Scoop; Angle Stiffener
A.S.L. — Abandon Ship Ladder
A.S.R.V. — Angle Stop Radiator Valve
Assm. — Assembled
Asst. — Assistant
A.S.T.T. — Air Separating and Test Tank
A.S.V. — Angle Stop Valve
A.T. — Air Tight
A.T.D. — Air-Tight Door
Av. Lub. — Aviation Lubrication
B. — Berth (2-B would mean Two Berths)
Bal. — Balance
Base L. — Base Line
Bat. — Batten
B.Bd. — Bulletin Board
B.C.B.H. — Boiler Casing Bulkhead
B.Dk. — Bridge Deck
Bdry. — Boundary
B.E. — Beveled Edge
Bel. — Below
Bet. — Between
Bev.Bd. — Bevel Board
B.H. (D.) — Bulkhead (see also Bhd.)
Bhd. — Bulkhead
Bil.K. — Bilge Keel same as Rol.K.
Bkt. — Bracket
Bl — Base Line (drawn with one letter partly over the other)
B.L. — Base; Bow Line
B.O.P. — Brine Overboard Pump
Boss. Fr.Aft. — Bossed Frame Aft
Boss.Plt. — Boss Plate
B.Rm. — Boiler Room
Br.Dk. — Bridge Deck
B.S. — Butt Strap
Btk.L. — Buttock Line
Bu., Bur. — Bureau
B.W. — Butt Weld
Bx.K. — Box Keel
Cab't. — Cabinet
Cam'r. — Camber
C.&R. — Construction and Repair
Car. — Carpenter
C.D. — Cofferdam
C.Fr. — Cant Frame
Ch., Ch.V. — Check Valve
Cir. — Circumference or Circulating
Ck., Csk. — Countersink
Ck.O.S. — Countersink Other Side
Ck.T.S. — Countersink This Side
℄ — Center Line
Cl. — Collar
Clk. — Calk
Col.Bh. — Collision Bulkhead
Comp. — Compartment

Comp-Air — Compressed Air
Cont. — Constant; Continuous
Cont.V. — Control Valve
C.P. — Coaling Port
C.R. — Curtain Rod
C.R.S. — Corrosion-Resist
C.Sk. — Countersink Holes
C.Sk.O. — Countersink Holes Over
Csk. O.S. — Countersink Other Side
Csk.T.S. — Countersink This Side
C.T. — Conning Tower
C. to C. — Center to Center
Cu. — Copper
C.V. — Check Valve
C.W. — Cold Water; Continuous Weld
D. — Down (Used around hatches with indicator line)
D.A.E. — Distilled Air Ejector
D.B.R. — Double Book Rack
Dblr. — Doubler
D.C. — Deck Covering
D. Cond. P. — Distiller Condensate Pump
Det. — Detail
D.F. — Drinking Fountain
Dia. — Diameter
Dia. L. — Diagonal Line
Disch. — Discharge
Div. — Division
D.K. — Duct Keel or Box Keel
Dk. — Deck
Dk.Drn.V. — Deck Drain Valve
D.L. — Dead Light
Dn. — Down
D.O. — Diesel Oil
Dr. — Door
Drn. — Drain
D.T. — Dust-Tight
Dt.C.Sk. — Don't Countersink
D.W. — Drainwater
E. — Evaporator
E.C.Dn. — Electrical Cables Down
E.F.P.— Evaporator Feed Pump
Elev. — Elevation
Emer. — Emergency
Eng.Fdn. (Found.) — Engine Foundation
Eng.Rm. — Engine Room
E.R.Bh. — Engine Room Bulkhead
Exp.M. — Expanded Metal
Exp.T. — Expansion Trunk
F. — Far
F.B. — Flat Bar
F.Cant. — Forward Cant Frames
Fdn. — Foundation
F.E. — Forward End
Fe. — Iron
Fe.Bd. — Freeboard
F.K. — Flat Keel
Fl. — Floor
Flg. — Flange
Flg.Plt. — Flange Plate
Flo.B. — Floor Beams
F.O. — Fuel Oil
F.O.&B. — Fuel Oil and Ballast
Focl.Dk. — Forecastle Deck
For., For'd — Forward
For'd.B. — Forward Body
F.P. — Fire Plug; Forward Perpendicular
F.Plt. — Face Plate
F.Q.A.W.T. — Flush Quick-Acting Watertight
Fr. — Frame
F.T. — Fume-Tight
Ft. — Feet
F.W.D.P. — Fresh Water Distributing Pump
Fwd. — Forward
F.W.T. — Feed Water Tank
F.W.T.H. — Flush Watertight Hatch
G. — Gangway
G.P.M. — Gallons per minute
G.S.H.V. — Globe Stop Hose Valve
G.S.L.C.V. — Globe Stop Lift Check Valve
G.S.R.V. — Globe Stop Radiator Valve
G.S.V. — Globe Stop Valve
G.V. — Gate Valve
Gd.R. — Guard Rail
Galv. — Galvanize

Gar.Str. — Garboard Strake
Gen. — Generator
Gen'l — General
Gir's — Girders
H. — Hatch; Hull
H.B. — Hose Bibb
H.D. — Hatch Door
H.L. — Horizontal Line
H.P. — Hawse Pipe; High Pressure
H.Rd. — Half Round
H.S. — Hinged Shelf
H.S.C.V. — Horizontal Swing Check Valve
H.T.S. — High Tensile Steel; Heat-Treated Steel
H.W. — Hot Water
H.W.T. — Hot Water Tank
Hat. — Hatch
Hd. — Head
Hf.Bh. — Half Breadth
H'l's — Holes
Hose C. — Hose Connection
Hose R. — Hose Rack
Htg. — Heating
I. — I Beam
I.B. — Inboard; Inner Bottom
I.D. — Inside Diameter
I.K. — Inner Keel
In. — Inch
In.Bd., Inbd. — Inboard (also I.B.)
In.Bot. — Inner Bottom
In.Dia. — Inside Diameter
Insul. — Insulation
Int. — Intermittent
Interl'k'd — Interlocked
Jog. — Joggle
K. — Keel
K.P. — King Post
K.P. — Keel Post
Knu. — Knuckle
L. — Lavatory; Line
L.B.P. — Length Between Perpendiculars
L.D. — Load Draft
L.D.B. — Light Distribution Boxes
L.Dk. — Lower Deck
L.H. — Lightening Hole
L.L. — Leave Loose
L.L.L. — Light Load Line
L.L.W.L. — Light Load Water Line
L.O. — Lubricating Oil
L.O.A. — Length Overall
L.P. — Low Pressure; Label Plate
L.S. — Left Side
L.W.L. — Load Water Line
Lb. or # — Pound
Ldg. — Landing
Leg. Bln'k — Legal Blank
Lin. — Liner or Linoleum
Lin.(L) — Light Linoleum
Lin.(M) Medium Linoleum
Lkr. — Locker
Longl. — Longitudinal
Long's — Longitudinals
Lub. — Lubricating
M.B. — Molded Breadth
M.D. — Molded Depth
M.Dk. — Main Deck
M.E. — Molded Edge
M.H. — Manhole
M.L. — Molded Line
M.P. — Mooring Pipe
M.T. — Mail Tray
Mach. — Machine
Mach'y — Machinery
Mag. — Magazine
Mar.Plt. — Margin Plate
Max. — Maximum
Med. — Medium
Mi.Dk. — Middle Deck
Min. — Minimum
Mk. — Mark
Mld. — Molded
Mn.Drn. — Main Drain
Mn. — Manganese
Mo. — Mold
Mrk. — Mark
N. — Near
N. & F. — Near and Far
Ni. — Nickel

Ni.S. — Nickel Steel
N.S.T. — Non-Slip Tread
N.T.D. — Non-Tight Door
N.V. — Needle Valve
N.W.T. — Non-Watertight
No. — Number
O.B. — Outboard
O.D., O.Dia. — Outside Diameter
O.Dk. — Observation Deck
O.G. — Operating Gear
O.G.Dk.P. — Operating Gear Deck Plate
O.K. — Outer Keel
O.S. — Opposite Side
O.S.T.I. — Other Side to Iron
O.T. — Oil-Tight
Off.C.L. — Off Center Line
On.C.L. — On Center Line
Op. — Operator
Opp. — Opposite
Opp. H. — Opposite Hand
Outbd. — Outboard
Ov.Bd. — Overboard
Ov.Fl. — Overflow
P. — Port
P.C. — Pitch Circle
P.Dk. — Poop Deck
P.Mk. — Pitch Mark
Pant. Stg's — Panting Stringers
Per., Perp. — Perpendicular
Pl., Plt. — Plate
Pl.Ck. — Plug Cock
Plat. — Platform
Plfm. — Platform
Prot.Dk. — Protective Deck
Pt. — Point; Port
Pb. — Lead
Q.A.D. — Quick-Acting Door
Qtrs. — Quarters
R.S. — Right Side
R.B.L. — Raised Base Line
R.F.W. — Reserve Feed Water
R.N.T.H. — Raised Non-Tight Hatch
Ra.K. — Raised Keel
Rad. — Radius
Ref. — Reference
Refrig. — Refrigerator
Rel.V. — Relief Valve
Rev.S. — Reverse Stiffener
Rm. — Room
Rol.K. — Rolling Keel or Fin
R'ts — Rivets
S. — Sink or Starboard
S.D.H. — Soap Dish Holder
S.F.W.T.H. — Semi-Flush Watertight Hatch
S.L. — Safe Locker
S.P. — Stern Post
S.R. — Storage Room
S.S. — Slop Sink
S.T. — Sounding Tube
S.T.A. — Shaft Tunnel Alley
S.T.S. — Special Treated Steel
S.W. — Salt Water or Steel Wire
San. — Sanitary
Scr.Bh. — Screen Bulkhead
Sec.L. — Sectional Line
Sect. — Section
Separ.T. — Separating Tank
Sett.T. — Settling Tank
Sh. — Shore
Shl.Dk. — Shelter Deck
Shr. — Sheer
Spec. — Special or Specifications
Specs. — Specifications
Spkg. — Sprinkling
Sq. — Square
St. — Strainer
St.M. — Set Mark
Stanch. — Stanchion
S.T.P. — Salinity Test Pot
Sn. — Tin
Stg's — Stringers
Stiff. — Stiffener
Str. — Stringer
Suct. — Suction
Swas.Plt. — Swash Plates
T. — Top
T.C.V. — Temperature Control Valve; Temperature Check Valve

T.R. — Tangent Radius (This is found on pipe detail drawings, and is thus explained)
T.S. — Top Side
T.S.T.I. — This Side to Iron
T.T. — Tank Top
Temp. — Template
Thks. — Thickness
Tk. — Tank; Thick
Tran.Gir — Transverse Girders
T.P.H. — Toilet Paper Holder
Trans. — Transfer; Transformer; Transverse
U.Dk. — Upper Deck
Und. — Underneath
Ur. — Urinal
V. — Vent; Void
V.C. — Vertical Cap
V.D.L. — Ventilation Dead Light
V.K. — Vertical Keel
V.G.R. — Vertical Grab Rod
V.S. — Vapor Separator
Vert. — Vertical
W.C. — Water Closet
W.D.Dr. — Weather Deck Drain
W.L. — Water Level; Water Line
W.P. — Wash Port
W.R. — Wardroom
W.R.H.A. — Winch Resistor House Aft
W.R.H.F. — Winch Resistor House Forward
W.R.H.M. — Winch Resistor House Middle
W.R.S.Rm. — Wardroom Stateroom
W.T. — Watertight
W.T.D. — Watertight Door
W.T.F. — Watertight Flat
W.T.Tr. — Watertight Trunk
Wt. — Weight
X. — Distance Below Deck
Y. — Distance Above Deck
Zn. — Zinc

APPENDIX IV
UNDERWRITER'S PIPE-TEST REGULATIONS

Tests are required on all piping after installation in the vessel, and they are to be performed in the presence of the owners, inspectors or representative and the U. S. Maritime Commission Inspector.

In general, these tests are to be conducted before the application of lagging if practicable. However, if the installation is subjected to a working fluid test that may present a fire or injury hazard, it may be performed after portions of the lagging between pipe joints have been applied.

Typical Test Specifications for a Certain Type of Ship Follow

The assemblies shall be subjected to the following test and working fluid pressures and temperatures:

The pressure specified shall be maintained for sufficient time to permit an adequate and detailed inspection of the system. In cases where it is necessary to remove the pressure to effect repairs, the test pressure shall be applied again after the leaks have been repaired.

Air Piping shall be tested with air pressure at 150#/□″ Ga. Static drop test with air at 100#/□″ Ga. for 2 hours. The pressure will be observed and all leakage shall be corrected.

Atmospheric Escape Piping shall be tested under service conditions with the accumulation test of the boiler.

Auxiliary Exhaust Steam Piping shall be tested with steam at 10#/□″ Ga.

Auxiliary Steam Piping shall be tested hydrostatically at 265#/□″ Ga. followed by steam test at 220#/□″ Ga.

Bilge and Ballast Discharge Piping shall be tested with air or water at 150# pressure.

Bilge and Ballast Suction Piping shall be tested with air or water at 100# pressure.

Bleeder Steam Piping shall be tested at the maximum pressure under full load conditions.

Boiler Blow Piping shall be tested with steam at 565#/□″ Ga.

Circulating Water Piping (Salt Water Piping) shall be tested hydrostatically 30#/□" Ga.

CO_2 Fire Extinguishing Piping

1. CO_2 piping shall be tested up to the stop valves with air or CO_2 (dischargi one or more CO_2 bottles if high pressure air is not available) with a pressu of not less than 1000#/□" Ga. If it is necessary to heat the CO_2 bottles obtain the required pressure, the bottles shall be heated by placing them in h water. A torch must not be used for this purpose.

2. The distribution lines shall be plugged and tested with air or CO_2 preferabl at a pressure of 1000#/□" Ga. but not less than 600#/□" Ga.

3. Piping used for smoke detecting shall be plugged and tested with air 100#/□" Ga. Special care shall be taken after this test to see that the plugg lines are unplugged and reconnected to their perforated pipes and accumulato and air or gas blown through them.

Contaminated Drain Piping shall be tested at 100% of working pressure und service conditions and also up to the traps at 75#/□" Ga. hydraulic.

Deck Drain Piping and Scuppers shall be tested hydrostatically under the ma mum head obtainable by filling.

Diesel Oil Piping shall be tested hydrostatically at 120#/□" Ga.

Engine Exhaust Piping, Auxiliary Diesel Engine is to be tested with air to a pr sure of 10 pounds per square inch.

Evaporating Plant Piping shall be tested at 100% of working pressure under se ice conditions. Condensate piping will be tested hydrostatically at 10#/□" Ga.

Feed Discharge Piping to boiler (including H.P. Feedwater Heater) shall be test hydrostatically at 900#/□" Ga.

Feed Suction and Condensate Piping shall be tested at 105#/□" Ga.

Fire System Piping shall be tested hydrostatically at 140#/□" Ga.

Flushing and Sanitary Piping shall be tested hydrostatically at 130#/□" Ga.

Fresh Water Piping shall be tested hydrostatically at 90#/□" Ga.

Fuel Oil Filling Piping shall be tested hydrostatically if practicable to 100#/□ Ga. pressure. Where it is impossible to do so it shall be tested with the tank.

Fuel Oil Overflow and Vent Piping shall be tested with the tank.

Fuel Oil Heating Coils shall be tested hydrostatically at not less than 500 pou per square inch Ga. and the welds are to be hammered while under this pressu They shall also be tested with steam at 100 pounds per square inch Ga.

Fuel Oil Service Discharge Piping shall be tested hydrostatically at 650 pounds per sq. in. Ga. Fuel Oil Service Suction piping shall be tested at 100#/□" Ga.

Fuel Oil Transfer and Stripping Piping shall be tested hydrostatically at 100 pounds per sq. in. Ga.

Hydraulic Piping, Oil, Water, etc. not otherwise specified shall be tested hydrostatically at 150% of working pressure.

Lubricating Oil Piping shall be tested hydrostatically or by air at 100#/□" Ga.

Lubricating Oil Heating Coils shall be tested hydrostatically at 200#/□" Ga.

Main Steam Piping shall be tested hydrostatically at 1044#/□" Ga. and also with steam at 565#/□" Ga. The steam test will be made at the same time and pressure of the boiler test. (During Dock Trial).

Refrigerating Plant Piping (Freon) shall be tested with a mixture of dry seal tube Nitrogen, or other suitable gas and Freon, at 200 pounds per square inch Ga.

Soil Piping shall be tested hydrostatically at the maximum head obtainable.

Sounding Tubes and Air Escapes shall be tested with the tanks.

Sprinkler System (Fire) Piping shall be tested hydrostatically at not less than 150 lbs. per sq. in. for two hours.

Steam Drain Piping shall be tested with the systems up to traps or drainators. Beyond traps or drainators it shall be tested under service conditions.

Steam Heating and Constant Service Piping shall be tested with steam at 65#/□" Ga. pressure with radiators and unit heaters cut in.

Steam Out and Smothering Piping shall be tested with steam or air at 175#/□" Ga. pressure.

Telemotor Piping shall be tested at 500#/□" Ga.

Turbine Drains, Vents and Gland Seal Piping shall be tested at 100% of working pressure under service conditions.

Suction lines, excepting oil lines, that are never used for discharge shall be tested at 30 pounds per square inch, but where they can be used for discharge, they shall receive the same test as the discharge service.

APPENDIX V

This chart illustrates the various valve symbols used on piping blueprints. These symbols are the accepted standards of the United States Maritime Commission. The pipefitter should become acquainted with the meanings of these valve symbols if he expects to be able to read piping blueprints.

STANDARD VALVE SYMBOLS	
SYMBOLS	DESCRIPTION
	ANGLE VALVE
	ANGLE CHECK VALVE
	BACK PRESSURE VALVE
	BLOW-OFF VALVE
	CHECK VALVE
	CHRONMETER VALVE
	CROSS VALVE
	EXPANSION VALVE
	GATE VALVE
	GLOBE VALVE
	HOSE VALVE
	HOSE GATE VALVE
	POP SAFETY VALVE
	PRESSURE REDUCING VALVE
	PRESSURE REGULATING VALVE
	RADIATOR VALVE
	RELIEF VALVE
	SCREW-DOWN CHECK VALVE
	STOP-CHECK VALVE
	SWING CHECK VALVE

FIG. 383 — *Standard Valve Symbols*

APPENDIX VI
DISTINCTIVE MARKING FOR PIPING
AMERICAN MARINE STANDARDS—SPEC—16

General Notes

1. Pipe lines, the purpose of which is not obvious without marking, shall be marked at intervals throughout the ship with distinctive colors, to designate their function in the manner indicated by Plates 1, 2, and 3.

2. The markings shall consist of painting the edges of flanges adjacent to valves and of such other flanges on a pipe line as deemed necessary for convenient identification of the function of the pipe, also bands of distinctive colors and of various widths on the pipe itself on both sides of each valve or flange selected for marking.

3. The white painted bands on flooding pipes are supplemented by a distinctive symbol painted in red as indicated on Plate 2.

AMERICAN MARINE STANDARDS COMMITTEE - WASH. D.C.

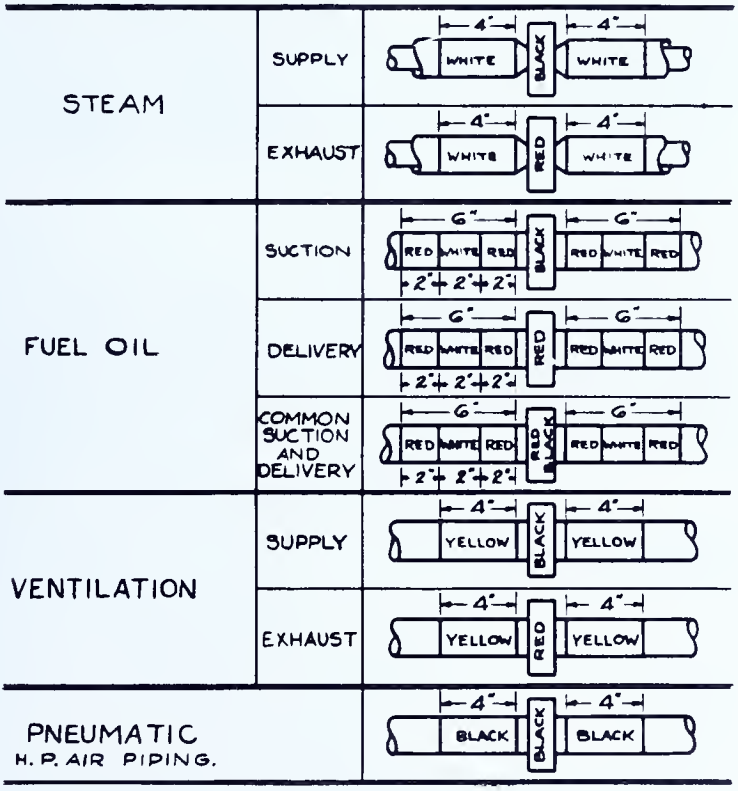


Plate 1

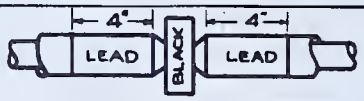
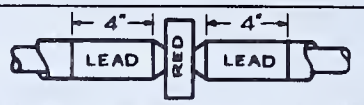
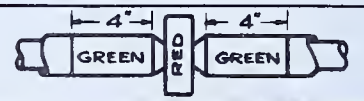
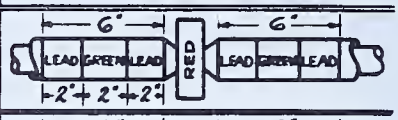
FRESH WATER STEAM & HAND PUMP SUCTIONS & DELIVERIES FRESH WATER MAIN & BRANCHES.	SUCTION	
	DELIVERY	
SALT WATER SEA SUCTIONS & DELIVERIES FLUSHING MAIN & BRANCHES.	SUCTION	
	DELIVERY	
HOT WATER		
REFRIGERATED WATER		
FIRE MAIN		
FLOODING FOR TANKS & COMPARTMENTS.		

Plate 2

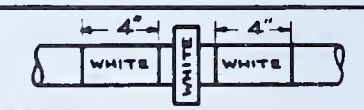
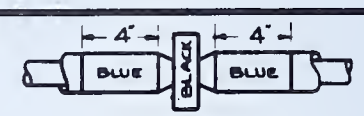
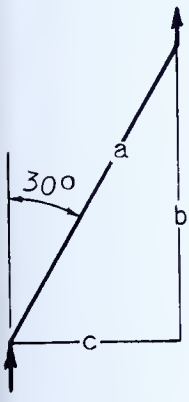
MAIN & AUXILIARY DRAINS SCUPPERS, FLOOR & OTHER DRAINS, AIR ESCAPES & SOUNDING TUBES.		
HYDRAULIC TELEMOTOR SYSTEM.	SUPPLY	
	EXHAUST	
FREON FOR REFRIGERATION.		
CARBON DIOXIDE (CO_2) FOR FIRE EXTINGUISHING.		

Plate 3

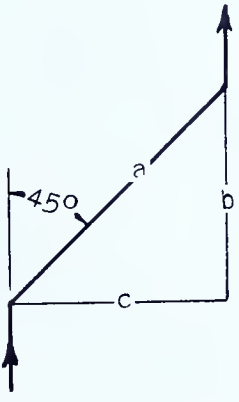
APPENDIX VII
45° & 60° OFFSET CHART

The 45° and 60° offset chart shown on the opposite page may be used to quickly find the center-to-center distances of offsets up to six feet. The chart is practically self explanatory. By following the dimensions around the curve until the amount of offset width is obtained, the width between centers will be given opposite the offset width.

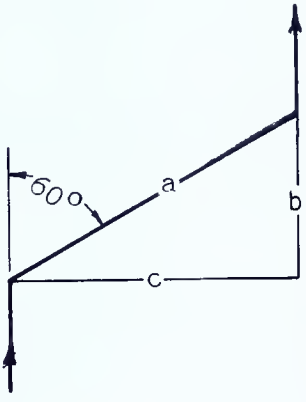
The chart gives the center to center measurements of 45° and 60° offsets having widths up to 6″. For finding offsets out of the range of this chart or for 30° offsets, use the following method.



30° Offset



45° Offset



60° Offset

TO FIND a WITH c GIVEN

Multiply c by 2	**Multiply c by 1.414**	**Multiply c by 1.154**

TO FIND a WITH b GIVEN

Multiply b by 1.154	**Multiply b by 1.414**	**Multiply b by 2**

TO FIND c WITH b GIVEN

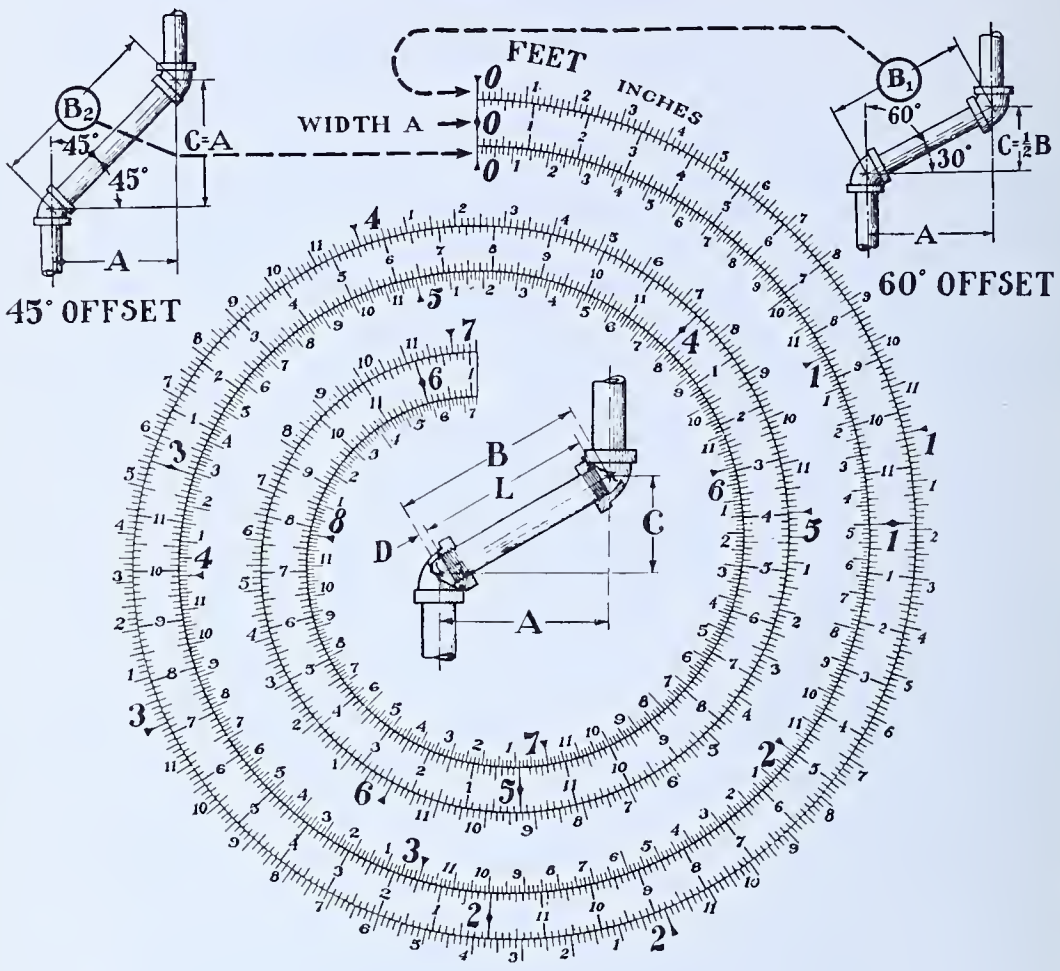
Multiply b by .577	**b equals c**	**Multiply b by 1.732**

TO FIND b WITH c GIVEN

Multiply c by 1.732	**c equals b**	**Multiply c by .577**

* 45° & 60° Offset Chart

Reading to ⅛ Inches



To determine the actual length of pipe, *L*, to use for length *B*, find in the tabl below the amount to deduct for the desired pipe size and subtract it from length *B* For example, using the chart a 45° offset of width $A = 4'\ 2\frac{1}{8}''$ gives the length o run $B = 5'\ 10\frac{7}{8}''$ center to center. If it is a 2″ pipe then using the table below fin the amount to deduct is $1\frac{7}{8}''$. Subtracting this from $5'\ 10\frac{7}{8}''$ gives 5′ 9″ as th length of pipe to cut, *L*.

FOR USE WITH CRANE STANDARD CAST-IRON SCREWED FITTINGS

Pipe size	Inches	¼	⅜	½	¾	1	1¼	1½	2	2½
45° deduct	Inches	¾	⅞	¾	⅞	⅞	1¼	1½	1⅞	2
60° deduct	Inches			1	1	1⅛	1½	1⅞	2¼	2½

Pipe size	Inches	3	3½	4	5	6	8	10	12
45° deduct	Inches	2⅜	2⅝	3	3⅝	4¼	5⅝	7⅛	8½
60° deduct	Inches	3		3¾	4½	5½	9⅛	9⅛	

NOTE — The above figures represent 2x*D*. To find *D* divide by 2.

*Courtesy Crane Co., Chicago.

APPENDIX VIII

APPLIED ARITHMETIC

Numerical Conversion (Decimals)

Decimal equivalents for fractional parts of an inch are encountered in all mechanical work. Circumferences are calculated or taken from already computed reference charts; in either case the results are always in inches and decimal parts of an inch. These decimals must be converted into fractions accurately in order to lay out the work correctly.

The conversion of a decimal to a fraction is the reverse of the conversion of a fraction to a decimal. For clarity of explanation the latter is presented first.

How to Change a Fraction to a Decimal

PROBLEM: Change 9/64 to a decimal.

Solution: Divide the numerator by the denominator as follows:

Note: The numerator is the part of the fraction above the horizontal line. The denominator is the part of the fraction below the horizontal line.

For example:

9 (Numerator)

64 (Denominator)

```
 64 | 9.000000 | .140625
      64
      260
      256
        400
        384
          160
          128
            320
            320
```

Accordingly, .140625 is the decimal equivalent of 9/64.

How to Change a Decimal to a Fraction

PROBLEM: Change .140625 to a fraction the denominator of which is 64 (sixty-fourths).

Solution: Multiply the decimal by the denominator of the desired fraction (64).

.140625
64
562500
843750
9.000000 (Answer in number of 64ths.)

Accordingly, 9/64 is the fractional equivalent of .140625.

For convenience any fractional part of an inch may be used; those shown on the mechanic's rule will be the most practical, as 1/64, 1/32, 1/16, 1/8, etc. For those wishing to learn this convenient method, it is well to practice with fractions like 1/64 and 1/32. It is always easier to multiply the decimal by 64 and then reduce the fraction to a denomination that is considered close enough for the job than to reduce the decimal directly.

Thus, .45312 x 64 = 28.999 sixty-fourths or 29/64ths. If multiplied by 32, .45312 x 32 = 14.4998 thirty-seconds, i.e., 14½/32nds. If multiplied by 16, .45312 x 16 = 7.2499 sixteenths, i.e., 7¼/16ths. This is an illustration of the convenience of reducing to 64ths.

The same rule may be applied to the decimals of a foot by multiplying the decimal by 12.

Extracting Square Root

GENERAL INFORMATION

On many jobs it is necessary to find diagonal or slanting distances. In the majority of cases these distances may be readily measured with a folding rule, a steel tape, or a measuring stick. There are certain jobs that can not be measured in this way because of temporary obstructions or because the size of the job may be beyond the capacity of the measuring tool. For example, it may be necessary to determine whether a bulkhead is, or is not, squared with the position of the deck. Then, too, it may be necessary to know if certain vertical constructions are square with a horizontal member such as special staging or angular bracing. When it becomes necessary to take measurements and check jobs of this nature, the fundamental principles of square root may be employed. To understand these methods of measuring and checking thoroughly, it will be necessary to know how to extract the square root of a number.

Root of a Number. The root of a number is one of the equal factors which produce it, or it is the number used to start with.

Root Sign. The radical sign $\sqrt{}$ is used to indicate a root. A small figure placed over the radical sign indicates how many equal factors are to be found.

$\sqrt{\ }$ 3 or $\sqrt[2]{3}$ means to find the square root of 3. The square root of 183184 will have three figures or three divisions, 18′ 31′ 84′; 21418384 will have four figures and four divisions, 21′ 41′ 83′ 84; and 9703225 will also have four figures and four divisions — 9′ 70′ 32′ 25′, but three divisions have two figures each, and one division has only one figure. Try finding the square root of 203401, marking it off into periods.

```
      20′  34′  01.   | 451 Ans.
  4   16
      434
 85   425
      901
901   901
```

Solution:

1. Separate the number into periods of two figures each, beginning at the decimal point.

2. Find the largest root which when squared will be contained in the left-hand period. This root is 4; place the 4 in the quotient as the first figure of the complete root.

3. Subtract the greatest square (16) from the first period (20), and bring down the next period with the remainder (4) making 434 for a new dividend.

4. Double the root already found (4) for a trial divisor ($2 \times 4 = 8$), and divide the trial divisor (8) into the new dividend (434) excluding the right-hand figure; this process ($43 \div 8$) gives 5. Place 5 after the 8 in the trial divisor, making 85; also place the 5 after the 4 in the quotient, making the quotient 45. Multiply the divisor (85) by the new root in the quotient ($5 \times 85 = 425$), and subtract this product from the new dividend ($434 - 425 = 9$). Then bring down the new period, which is 01, to make 901. Proceed as before for the next new root.

Try finding the square roots of the following:—

1. 784
2. 8464
3. 49729
4. 255036
5. 874225
6. 1799007056
7. 48841
8. 105976

Find Square Root of Decimals. To find the square root of a decimal, begin at the decimal point and mark off periods to the right.

```
     .29′16   | .54 Ans.
 5   25
     416
104  416
```

To find the square root of a whole number and a decimal, begin at the decimal point and mark off two-figure periods to the right; then mark off two-figure periods to the left.

```
                5'80.81'   | 24.1 Ans.
 2   4
    180
44  176
      481
481   481
```

Try finding the square roots of the following:

1. .625	4. 7832.25	7. 3124.81
2. .96721	5. 98.4064	8. .616225
3. .40401	6. 3.8416	9. 4.9284

Figure 384 shows two lines at right angles to each other. The length of one side is 4 in. The length of the other side is 3 in. The distance *A* may be found by using the principles of square root. The principles of square root are shown in Fig. 385.

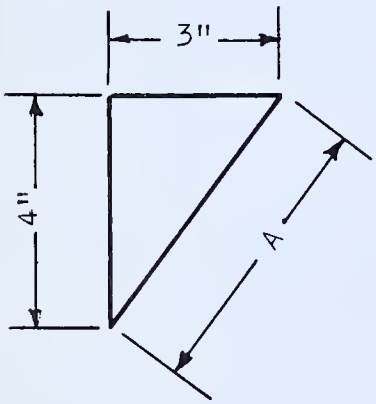


Fig. 384

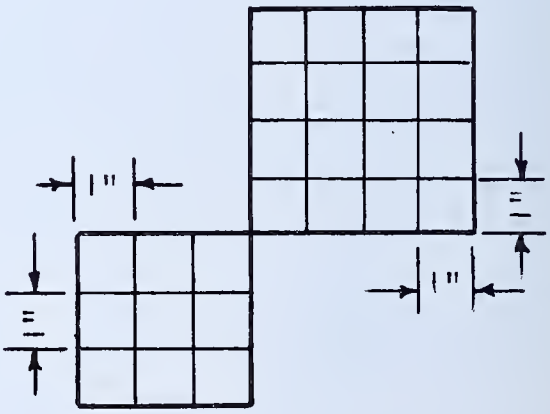


Fig. 385

A square is built around, or formed around, the first side, 4 in. each way. This is called "squaring" 4 in. The squares are 1 in. each way. A square is built the same way on the 3-inch side. The 3-inch side is now "squared."

Examine the number of squares. 16 squares will be formed in the large square; 9 squares will be formed in the small square. Add the squares together. There are 25 in all. Examine Fig. 386.

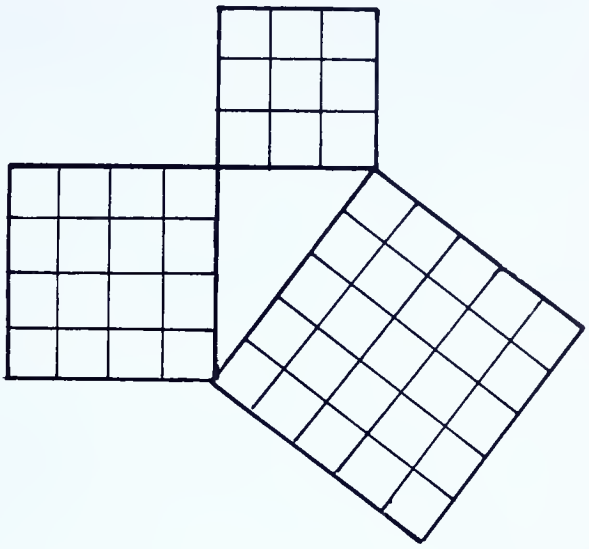


FIG. 386

Add the squares in the two small squares making 25 in all. Count the squares in the largest square. There are 25 squares of the same size in the smaller squares. The length of side *A* must be the square root of 25 which is 5, for 5 x 5 = 25.

From the example the standard rule for finding the length of the third side of a right-angled triangle follows:

RULE:

1. Square each side of the triangle.
2. Add the squares together.
3. Extract, or find, the square root of the sum of the squares.

The answer will be the length of the third side.

PROBLEM: Find the length of the slanting timber *a* shown in Fig. 387.

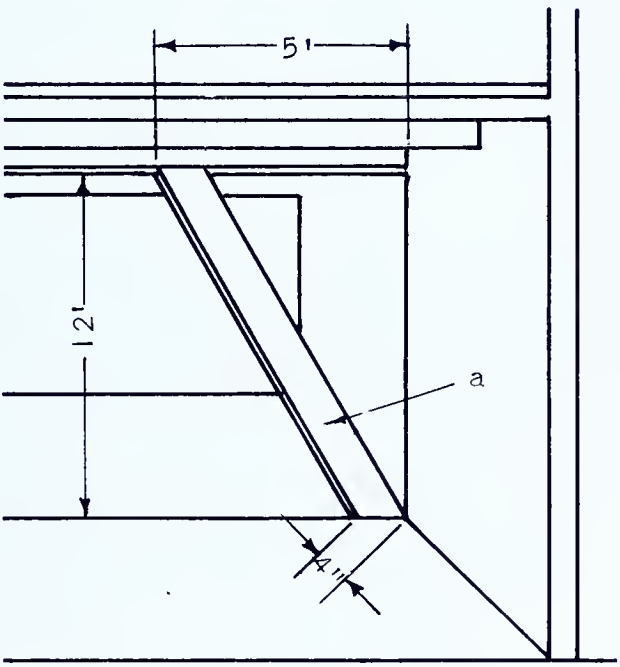


FIG. 387

A marine pipefitter is often required to obtain center-to-center distances of tubular objects or circular holes. The center-to-center distance between two pipes must be found or a bolt-center circle on a flange must be measured. At first thought, measuring from the center of a pipe or from the center of a hole would seem to be a tedious job. The solution is simple.

By examining the following sketches, Fig. 388, it will be seen that the center-to-center distance of equal-sized holes or tubes is the same as the edge-to-edge distance

of the members. It would be a difficult job to measure to the center of a hole bu measuring to the edge of a hole is a simple matter.

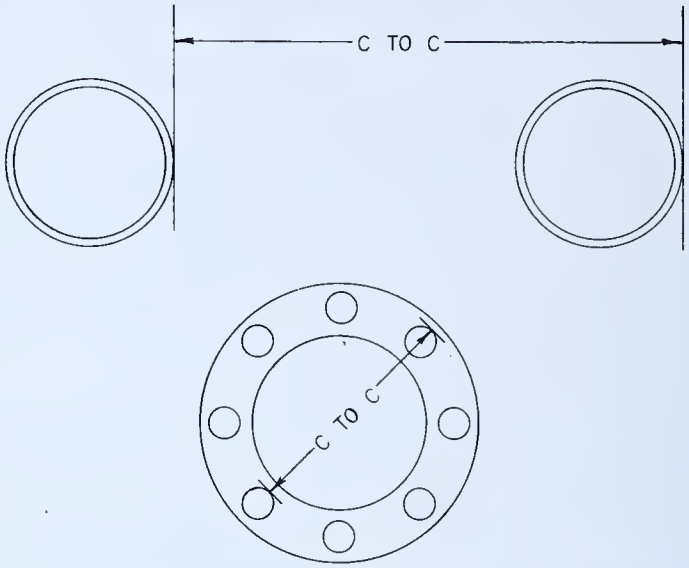


FIG. 388 — *Measuring Center-to-center Distance*

The pipefitter encounters in his daily work many problems which involve the use of simple arithmetic. A few examples of the more common types of such problems are given below.

When attempting to solve any problem that is new or apparently difficult always think it over carefully to determine just what is required.

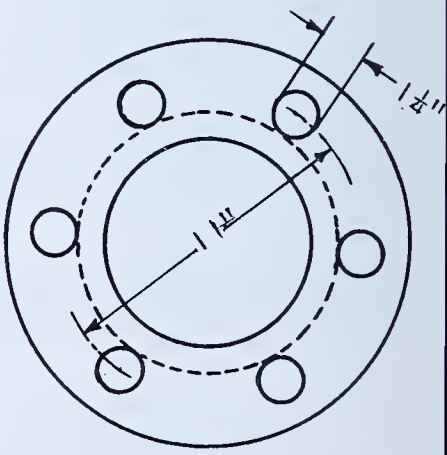


FIG. 389

PROBLEM 1

A blank disc is required to fit on the inside of the bolts on a certain flange joint. The bolt-center circle is 11″ diameter. The bolts are 1¼″ diameter. The problem then is to find the diameter of the circle which will just touch the sides of the bolts all around as shown by the dotted line in Fig. 389.

SOLUTION:

1. Diameter of bolt center circle is 11″.
2. Diameter of bolts is 1¼″.
3. Diameter of circle which will touch the bolts all around on the inside is $11 - (\frac{5}{8} + \frac{5}{8}) = 9\frac{3}{4}$″.

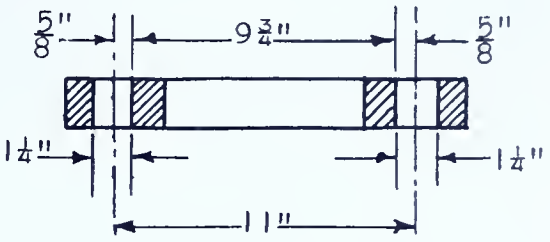


FIG. 390

Follow the steps through on Fig. 390. If the *BC* circle is 11″ and the diameter of the bolt is 1¼″ then adding two half-bolt diameters and subtracting the answer from 11″ give the distance from inside to inside of any two opposite bolts, which is 9¾″.

This solution can be shortened to: Dia. of *BC* circle − Dia. of bolt = 11″ − 1¼″ = 9¾″, the required diameter.

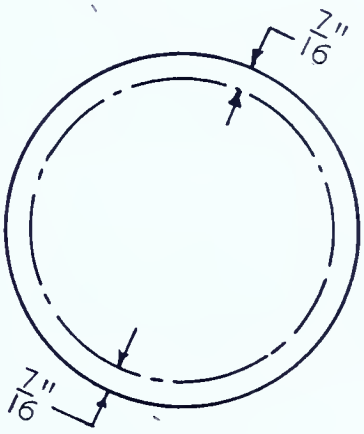


FIG. 391

Let it be assumed that a mistake was made in cutting the blank disc and that it is ⅞″ too large. The disc is then 7/16″ too large on each side. Scribe a line around the outside of the disc 7/16″ from the edge as in Fig. 391. Have the burner cut to the new line. The rule in this case is to take half the difference in diameter and scribe a line this distance from the edge all around the circle to arrive at the corrected diameter.

QUESTIONS

1. **What is the distance between the adjacent sides of two 1⅛″ diameter bolts which are located at opposite sides of 20″ bolt centers?**
2. **What is the radius of a circle which will just touch the inner sides of ¾″ bolts located on a 12″ bolt circle?**
3. **A blank disc must be reduced 3⅛″ in diameter. How much metal must be burned off each side, all around?**
4. **A blank disc should have been cut to 13⅛″ diameter. But the disc measures 11⅝″ diameter. How much under size was the blank cut, on a side?**

PROBLEM 2

Two 1½″ pipes run parallel to each other at a distance of 52″ apart, center to center. Let it be assumed a pipe *a* is to be connected to both of the pipes in Fig. 392 at an angle of 45°.

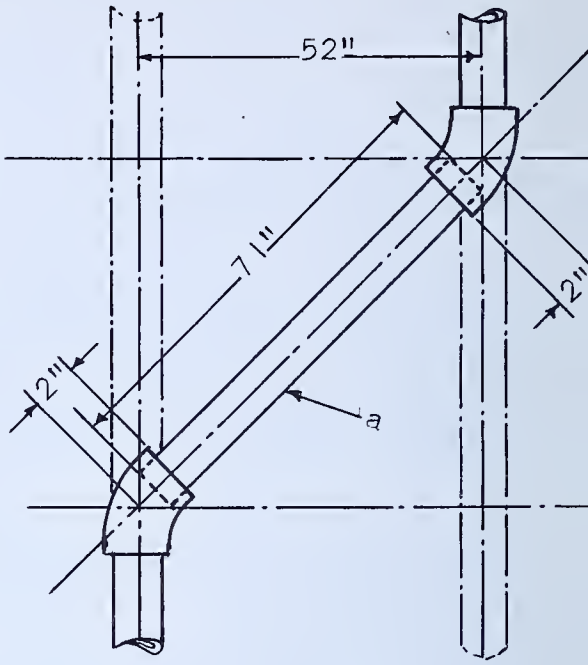


FIG. 392

If a diagonal is scribed from corner to corner of a square it will form an angle of 45° with any adjacent side of the square. See Fig. 394.

What is the approximate length of a piece of pipe that will be required to make the connection between the two 45° degree elbows shown in Fig 393?

When the dotted lines are scribed 52″ apart at right angles with the two parallel pipe center lines 52″ apart the dotted lines and pipe center lines form a square. The center line of pipe *a* in Fig. 392 becomes the diagonal as shown in Fig. 394.

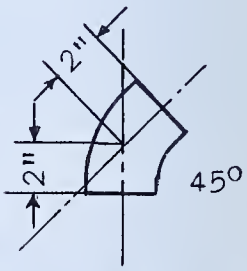


FIG. 393

The length of the diagonal can be found by finding the length of the hypotenuse of a right angle triangle, the base of which is 52″ and the altitude of which is 52″.

The diagonal of a square is 1.414 times longer than the length of one side of the square. Therefore the length of the diagonal of a 52″ square is 52 x 1.414 = 73.528 or 73½″ approximately.

It follows then that if the dimension of the ell shown in Fig. 393 is deducted from each end of the diagonal and a sufficient amount is added for thread, the result is the length of the diagonal pipe. About ¾″ is sufficient for thread. Then 73½ − (2 + 2) + ¾ + ¾ = 71″, the length of the diagonal piece of pipe.

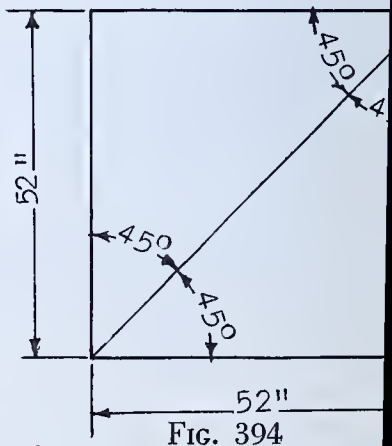


FIG. 394

QUESTIONS

1. **What is the length of the diagonal of a 37″ square?**
2. **The diagonal of a certain square is 29″. What is the length of one side of the square?**
3. **Two parallel pipes are to be connected by a diagonally placed pipe and two 45° ells. If the centers of the pipes are 21″ apart what is the approximate length of the pipe? (Disregard the ell dimensions.)**
4. **Two parallel pipes 28″ apart have to be connected with 45° ells and a union. Allow 1½″ for each ell and for each half of the union. What are the lengths of the two diagonally placed pipes?**

Checking a Square

Sometimes because of rough handling or accidental dropping, squares become warped or lose their quality of forming a 90° angle. A simple method for checking the squareness of a square is given here.

1. Using a chalk line on a clean space, mark down a straight line several feet long.
2. Place one edge of the square even with the chalk line and trace the other edge with a pencil.
3. Turn the square around so that the same edge rests on the chalk line but in the opposite direction.
4. Move the edge along the chalk line until the corner meets the penciled line. (See Fig. 395).
5. Draw a pencil line along the upright edge of the square.
6. The two lines should appear as one. If the lines branch away from each other, the square is not true. It may be ground square in the machine shop.

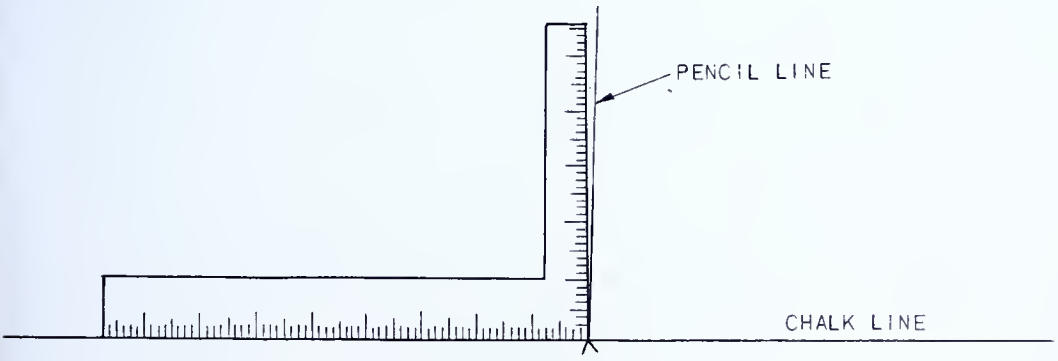


Fig. 395 — *Square Is Out of True*

Erecting a perpendicular (a line at right angles) to any line.

Two easy methods will be given here:

1. Using a square:

   If there is a square available place one leg of the square along the line from which the perpendicular is to be erected. Then with the outside corner of the square on the mark where the perpendicular is to be erected, mark off with soapstone along the outside of the square as shown in Fig. 396.

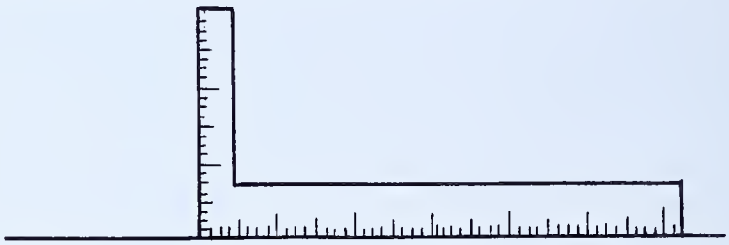


FIG. 396 — *Erecting a Perpendicular Using a Square*

2. Using trammels or a scriber:

   Set the trammels or scriber to any convenient length. Then by placing one point on the mark, scribe arcs on the working line or center line. Now using a larger opening on the trammels or scriber, scribe arcs using the mark on the center line as centers. Using a straightedge connect the point where these two arcs meet and the mark on the center line. This line will be perpendicular to the center line. See Fig. 397.

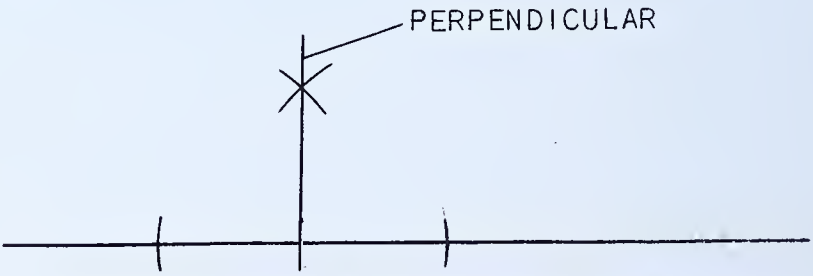


FIG. 397 — *Erecting a Perpendicular Using Trammels*

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